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Department of Applied Mechanics

Leonidas Samouladas

Regulatory Framework for Arctic Cruising

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Technology

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Supervisor: Professor Pentti Kujala, D.Sc. (Aalto University)

Instructor: Risto Jalonen, L.Sc. (Aalto University)

Author Leonidas Samouladas	
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Abstract

For the last 10 years the entirety of the shipping industry has start looking into the melting Arctic for opportunities to expand their activities. Regulatory authorities at the same time try to anticipate issues and address older well known problems in their legal texts. Last year a prominent cruise company had announced their plan to route one of their more luxurious ship for month long cruise through the infamous North Western Pass in Canadian Arctic in 2016. The ship will be biggest passenger ship ever to sail those waters. Meanwhile, IMO for the last 20 years is attempting to fill the regulatory gap of Arctic shipping with a mandatory Polar Code for the first time in regulatory history, a code that is going into effect in the next 2 years.

The purpose of this thesis is to review the current legal framework, understand the intricacies and prime motive behind creating it, evaluate its provisions wile comparing them to the documented challenges that the Arctic region is struggling with and propose changes in the current regulatory framework about passenger ships sailing into the Arctic waters.

In order to achieve such a lofty goal a long process was started for studding the Arctic regions, geography, climate, history of its inhabitants and the Arctic cruising industry, through all available resources (scientific reports, literature, opinion articles by specialist and more). The knowledge acquired by the process applied into a summary attempt to locate and catalogue the challenges that can be related with Arctic shipping and provide each of the member of that list with a short but thorough justification and background information. Six different categories of challenges were recognised ship safety, environmental protection, passenger safety, infrastructure, cultural and government and law.

For each of the six categories a second round of critique went on in order to identify and describe specific problems and finally focused the attention in nine problems that were in some cases combination of challenges from different categories. Specific legal texts related to those nine problems were recognised and studied. Then the problems analysed for their merit to acquire further legal regulation and/or protection by related regulatory provisions.

During that analysis the prominent factor of Risk management was recognised as a paramount. For that reason the proposed by the IMO Polar Operational Limit Assessment and Risk Indexing System) was studied and experimentally applied to the ship that will make the cruising trip next summer, with the use of historical Ice regime information and the route schedule provided by the owner company.

Finally in the last chapter details the conclusions of the study's deliberations and exhibits the proposal for regulatory changes for each of the cases.

Keywords Regulation, Framework, Arctic, Cruising, Rules, Risk, Management

Acknowledgements

This is the cumulating result of a long, challenging, but extremely interesting, fun and learning process that started almost three years ago when I committed to become a Maritime Engineer.

The support of my family was paramount and I thank them for it although they cannot read it and understand it in this first draft of the acknowledgements since it is in English.

I would like also to extent my gratitude to the teachers in both universities KTH and Aalto for the copious work aimed to teach me and the rest of my peer their art and lifetime experiences.

Particular thanks should be offered for one more time in writing to Professor Pentti Kujala D.Sc. and L.Sc. Risto Jalonen for their guidance, patience and assistance in authoring this paper.

Thank you

I would like to dedicate this small body of work to my recently deceased grandfather whose name I am wielding. For his exemplary life lessons in respect for life, duty and compassion to others in spite of circumstances historical or otherwise.

Rest in peace and don’t be too mad at me if I fall short of your example.

Helsinki 23.05.2015

Λεωνίδας Σαμουλαδάς / Leonidas Samouladas

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Abbreviations List

AC: Arctic Council
AECO: Association of Arctic Expedition Cruise Operators
AMSR-E: Advanced Microwave Scanning Radiometer - Earth Observing System
ANSR: Administration of Northern Sea Route
ARCO: Atlantic Richfield Company
AWPPA: Arctic Waters Pollution Prevention Act
BP: British Petroleum
BWM: Ballast Water Management
C: Concentration of Ice
CAFF: Conservation of Artic Flora and Fauna
CCGS: Canadian Coast Guard Ship
CLIA: Cruise Lines International Association
CIS: Canadian Ice Service
DEWL: Distant Early Warning Line
EEZ: Exclusive Economic Zone
HMCS: Her Majesty's Canadian Ship
HFO: Heavy Fuel Oil
IACS: International Association of Classification Societies
IMO: International Maritime Organization
IUCN: IUCN, International Union for Conservation of Nature
LME: Large Marine Ecosystem
MARPOL: Marine Pollution, short for International Convention for the Prevention of Pollution from Ships
M/V: Motor Vessel
NASA: National Space Association
NATO: North Atlantic Treaty Organization
NEP: North Eastern Pass
NOx: mono-nitrogen oxides
NGO: Non-Governmental Organization
NSIDC: National Snow and Ice Data Center
NSR: Northern Sea Route
NM: Nautical Miles
NWP: North Western Pass
PAME: Protection of the Arctic Marine Environment
PMOU: Paris Memorandum of Understanding (for Port State Control)
POLARIS: Polar Operational Limit Assessment Risk Indexing System
PC: Polar Code
PWOM: Polar Water Operations Manual
RIV: Risk Index Value
RIO: Risk Index Outcome
SAR: Search and Rescue

SOLAS: Safety of Life at Sea, sort for International Convention for the Safety of Life at Sea
SOx: Sulfur oxide
SS: Steam Ship
SWOT: Strengths Weaknesses Opportunities Threats
SMMR: Scanning Multichannel Microwave Radiometer
SSM/I: Special Sensor Microwave/Imager
UN: United Nations
UNCLOS: United Nations Convention on the Law of the Sea
WWII: World War the second

Abstract

The idea for this study started from the Crystal Serenity's cruise that is to be expected in summer of 2016. The intent was to study the pre-existing issues of the Arctic region related to cruise ships and identify the problems that such a large cruise ship will create for the Arctic. Then propose solutions in a form that would promote further discussion for establishing rules and regulations necessary for the safety of the ship, its passenger, the Arctic environment and the sustainable development of the big ship cruising project that seem to be under field testing.

This study is reviewing all available information about the Arctic region in a wide spread of fields. Shipping, climate, environment and human factor are all get some attention since a cruise ship and its operations interact with all this factors. Then the international law framework is evaluated for its efficacy and gaps, based on personal study and expert opinion. Recognizing the issues a Risk assessment is made with an example of the above mentioned ship and average previous year conditions for the Arctic area. A SWOT assessment is then used in order to plan legal strategy and finally it makes proposals for legal amendment and additions to specific already existing legal documents, while further studies are recommended in fields that through the study are identified for lack of information. The scope of the study is to promote further discussion.

Unaware at the point of idea conception of the latest legal developments (Polar Code final compilation) it is effectively shadowing the latest developments and to a degree verify or criticize the decisions made at the IMO committee task with improving the Arctic shipping legislation.

Introduction

During August 16 – September 17, 2016 the first large scale Arctic cruise will take place. The Crystal Serenity will follow a route, 500 NM inside the Arctic Circle, from Kodiak Alaska to New York. She will travel through the North Western Pass, around Alaska and into Beaufort Sea through the Canadian Arctic Archipelago and on to Greenland. Passengers will have a luxury expedition feeling as rare wild life like, polar bears, narwhals, musk oxen and Caribou might be observed during tundra trekking and kayaking events and spontaneous day expeditions.

The company states that: "Crystal's Northwest Passage heralds the beginning of a new era of exploration for the cruise line voted World's Best more than any other in history. As our inaugural expedition-style cruise, we've gone to great lengths to ensure the integrity of the experience—authentic discovery and pure adventure, as well as the careful respect of the remote communities we will be visiting."

The press, the cruising industry, and environmental protection agencies will observe closely the outcome of this experimental trip. It will be the first time that such a large cruise ship travels through the Arctic, till now usually they only approach Greenland for some photo opportunities. If it is a success then more of those cruises will be planned in the future bringing an unprecedented, amount and size of ships and human "exploration" activity in one of the most remote, hostile and ecologically sensitive region on the planet.

The mere presence of any kind of ship in any sea on the globe, create a host of issues that need to be addressed and sometimes regulated. The Arctic is one of the few places were that issues are more complicated than usual, because of the particular weather conditions and the presence of a multiyear sea ice sheet.

This study was motivated by those facts and designed in order to understand the realities of the Arctic, review the rules that currently regulate shipping activities in the region and then combine the new information into a constructive critique of the existing legal framework, intended to restart a serious discussion about Arctic shipping regulations in an effort to anticipate the challenges that the future will uncover for the region.

Scope

The scope of this work was to approach the region as a complex system, understand and analyse it in order to learn the relations between the parts of the whole and identify the issues that big cruising ships create for the region. For that a wide range of studies about the Arctic was reviewed encompassing all aspects of the region, humans, environment, weather and ice. Then the review and critique of existing law was performed taking into advisement the gained understanding of the region. In the following chapters the issues concerning the cruising shipping activities isolated and examined form an engineering point of view. The results of that analysis became the focus of a Risk evaluation performed about a not strengthen for ice operations ship traveling the Arctic summer waters. The conclusions of such an evaluation with the results of the legal framework review became the basis for a SWOT analysis aimed to formulate a regulation improvement strategy that is presented as the conclusion of this study.

Limitations

In the conception face of this study it became evident that a complete examination of all related to the Arctic cruising tourist industry issues could not be performed, as intended, for three reasons: First, the study is to be composed for a maritime engineering master program. Second the authors training was not including studies in humanities or oceanography that some issues required in order to provide detailed analysis and third, the amount of work demanded by such a goal was exceeding the given time limitation and intent of a Master Thesis study. Furthermore it is to be mentioned that the latest developments about the creation of the new mandatory Polar Code were not initially known and when they became known there was not a way to be followed more closely than the study of the comity reports and produced drafts of the amendment and a preview of proposed risk assessment method presented to the university students by Trafi, the Finnish transport safety agency.

1. The Arctic Region

The following chapter is designed for one reason only: provide all needed and available information in their latest possible form. That information is absolutely necessary in order to understand the challenges that the region offers to human activities and its importance to the rest of the globe, on all levels.

1.1. Geography

The term's origin is coming from the Greek word αρκτική (arktiki), "of the Bear, northern" and that from the word άρκτος (arktos), meaning bear. The name refers either to the constellation Ursa Major, the "Great Bear", which is prominent in the northern portion of the celestial sphere, or to the constellation Ursa Minor, the "Little Bear", which contains Polaris, also known as the North Star.

Arctic area does not have a unilateral definition; different criteria are used from different scientific disciplines. Astronomers and cartographers defined the region as the areas of the earth north of the Arctic Circle (66° 33'N), since is the limit latitude of the zone were the sun is never below or above horizon, during summer and winter solstice respectively. Of course earth's axial nutation is making the above mentioned value an average. Climatologist, define the region as the northern areas of the globe where the average temperature for the warmest month (July) is below 10 °C (isotherm); or even the areas north of the northernmost tree line that roughly follows the isotherm at the boundary of this region. Note that both of them are moving as a result of global warming.

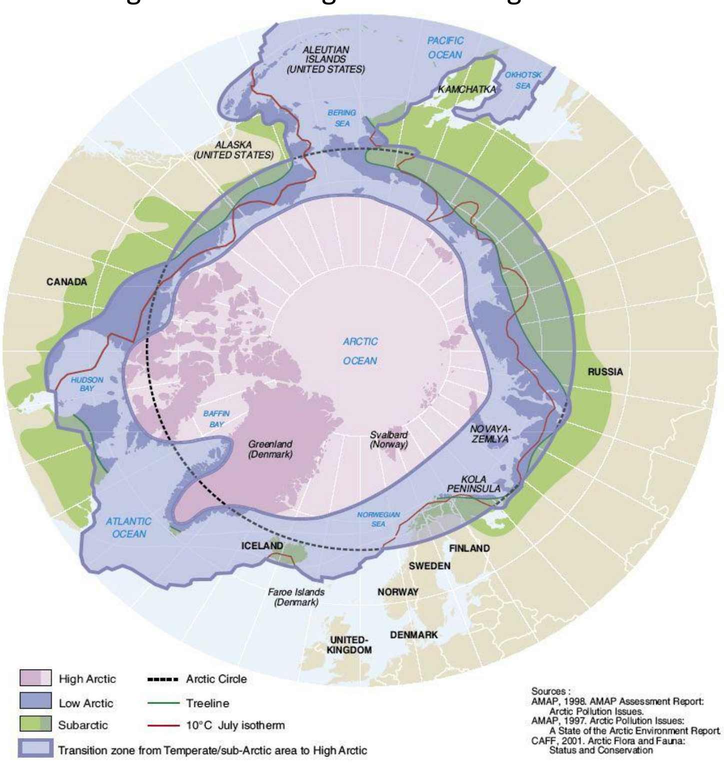

Figure 1 Arctic region limit by climate criteria (Source WWF,2015)

The Arctic includes the Arctic Ocean, an ocean with a seasonally varying ice cover, and the permafrost and subarctic zones of Alaska (U.S.A), Canada, Finland, Greenland (Denmark), Iceland, Norway, Russia and Sweden.

In cartography, the Arctic region is divided in the Arctic Ocean occupying the centre mass of the water area and in several coastal seas. Working from Greenland eastwards, the waters adjacent to the Arctic basin itself are Greenland Sea, Norwegian Sea, Barents Sea, White Sea, Kara Sea, Laptev Sea, East Siberian Sea and Chukchi Sea - the Eurasian part - Bering Sea, the Beaufort Sea, the waters within the Canadian Archipelago, Hudson Bay and Hudson Strait, Lincoln Sea, Baffin Bay, Davis Strait and Labrador Sea –in the North American continent side.

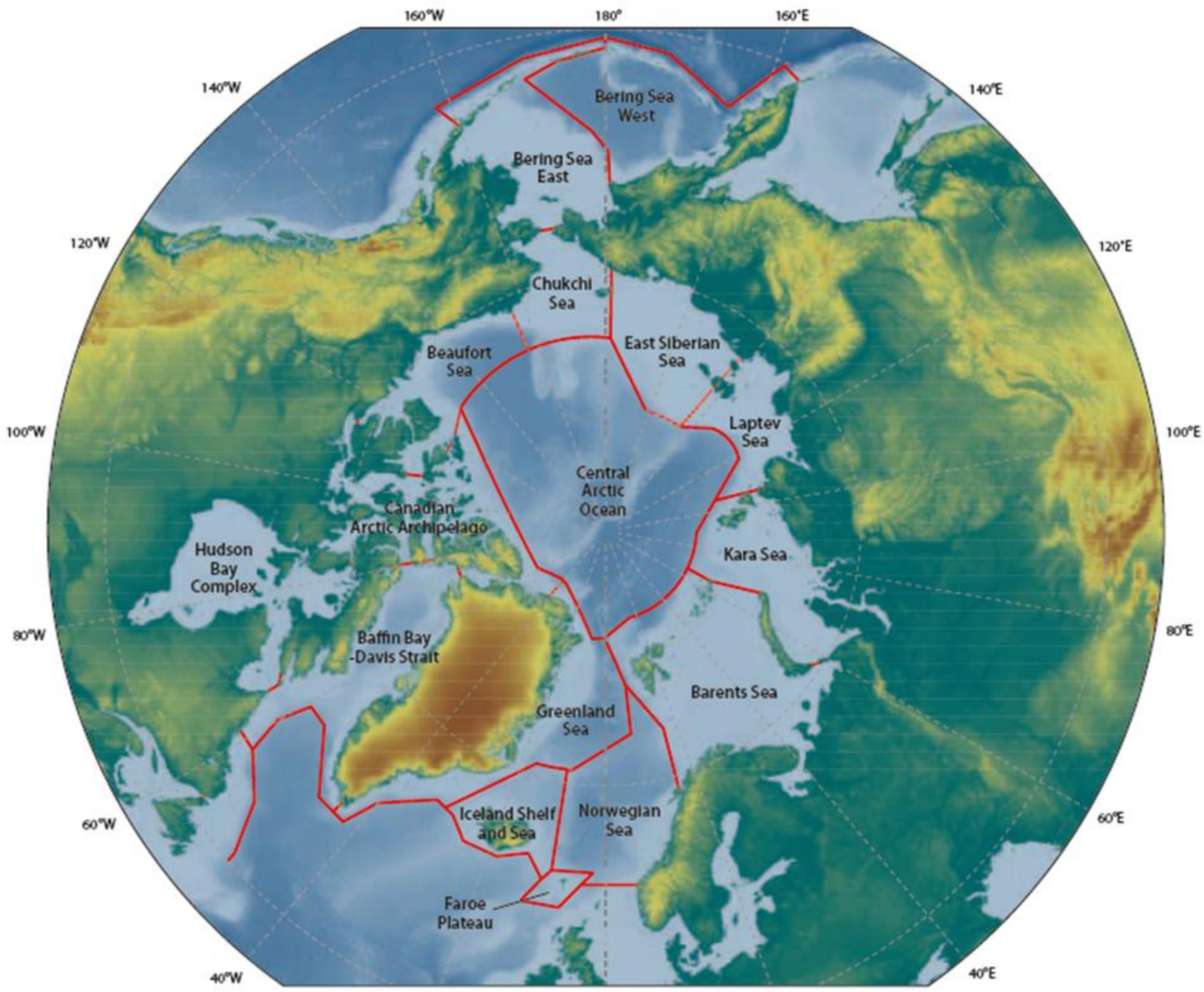

Figure 2: Arctic Seas (credit: AMSA 2009)

The Arctic Ocean's depth is defined by the two continental shelf that extent below its surface were depth is between 100 and 200m. The Eurasian is extending about 1000km into the Ocean and the North American about 200 km. The rest of the Arctic Ocean is between 4 and 4,5 km deep. Over all the average depth of the Arctic Ocean is 1,038 m with the deepest point at Litke Deep in the Eurasian Basin,(5,450 m).

For all intents and purposes International Maritime Organization (IMO) defines the Arctic waters in SOLAS regulation XIV/1.3 and MARPOL Annex I, regulations 11.46.2; Annex II, regulations 10.21.2; Annex IV, regulation 7.17.3; and Annex V, regulation 3.13.2, the following picture provide a visual representation.

Figure 3 Arctic waters according to IMO (credit IMO, MSC-385-94 , 2014)

1.2. Climatography

1.2.1. Climate

The Arctic's climate is characterized by long, cold winters, -5°C to more than -35°C with record lowest −68°C, and sort, cool summers, according National Snow & Ice Data Centre, ACIA (2004, Ch. 2) and AMSA (2009, Ch. 2.) which are heavily relied upon throughout this segment. The mentioned reports observe that the Arctic as mostly an ocean who is largely surrounded by land; Thus, the climate of the Arctic is moderated by the ocean water, which never drops below −2 °C. This relatively warm water keeps North Pole from being the coldest place in the Hemisphere, and it is part of the reason that Antarctica is much colder than the Arctic. In summer, the presence of the nearby water work in reverse, keeping coastal areas from warming as much as they might otherwise.

Low and high pressure systems distribution and their interactions throughout the year is another factor explaining the weather/ climate pattern of the Arctic, according to the reports. In winter two High pressure systems are forming over Siberia and the Yukon in Canada, while two Low pressure systems are established over the Gulf of Alaska in the North Pacific and Geographic North Pole North Atlantic extending into the Barents Sea, respectively. The pressure differences frequently induce, intense cyclonic storms moving in a general West to east direction. In summer, the Siberian high disappear, the Yukon high relocate over the Canadian Archipelago, and the Low pressure systems are weaken; The pressure differences are now smaller and the cyclonic activity declined, creating a benign Arctic summer environment, until October when the winter distribution starts to form again, temperature plummets and storms reappear, (AMSA 2009, Ch.2).

Figure 4: Portable weather station somewhere in arctic (source: fondriest.com, 2014)

The reports describe an annual precipitation as light, as most of the region receives less than 25 cm, and as expected most of it is snow. Only along exposed coastal regions in southern Baffin Island, western Greenland and northern Scandinavia are amounts greater than this regularly experienced. Gale force winds often stir up snow, creating the illusion of continuous snowfall. The snow accumulate in drifts or, in marine environment, along ice edges or other sea ice features creating additional or strengthening existing barriers to normal navigation. Virtually all snow disappears from everywhere in the summer, except in glacier areas.

Wind speeds over the Arctic Basin and the western Canadian Archipelago average between 4 and 6 m/s in all seasons. Stronger winds do occur during storms, creating whiteout conditions, but they rarely exceed 25 m/s in these areas (Przybylak 2003). The highest average is observed in North-Atlantic, Baffin Bay, Bering and Chukchi Seas, where the above mentioned cyclone activity is most common. On the Atlantic side, the winds are strongest in winter, averaging 7 to 12 m/s, and weakest in summer, averaging 5 to 7 m/s. On the Pacific side they average 6 to 9 m/s year round. Maximum wind speeds in the Atlantic region approach 50 m/s in winter (Przybylak 2003).

The climate in the Arctic has changed throughout time with the rest of the planets. It is estimated that 55 million years ago the Arctic supported subtropical ecosystems (Serreze and Barry 2005) and that Arctic sea-surface temperatures rose to about 23 °C during the Palaeocene Thermal Maximum. In the last ice age reaching its maximum extent about 18,000 years ago and ending by about 10,000 years ago, large regions of North America and Eurasia were covered by ice sheets similar to the one found today on Greenland.

Currently the Arctic is affected by the global warming, as it is the rest of the planet. A number of reasons advocate that those climate changes might be more enhanced in the Arctic, relative to the mid-latitudes and tropics. First, cold air holds less water vapour than warm air. In the Arctic, that translate into that a greater fraction of any increase in radiation absorbed by the surface goes directly into warming the atmosphere, when in the tropics, a greater fraction goes into evaporation. Second, the temperatures distribution in the Arctic atmosphere inhibits vertical air motion, which equals that the depth of the atmospheric layer that has to warm in order to cause warming of near-surface air is much shallower in the Arctic than in the tropics. Third, is the ice coverage feedback suggest that the receding ice expose darker surfaces over land that absorb more sunlight, leading to more warming. The reduction in sea-ice coverage, also lead to more energy being transferred from the warm ocean to the atmosphere. Finally, changes in atmospheric and oceanic circulation patterns caused by a global temperature change may cause more heat to be transferred to the Arctic, (ACIA 2004).

1.2.2. Ice coverage

Sea ice is mostly frozen seawater that floats on the ocean surface. Multiyear ice is blanketing almost permanently millions of square kilometres, of the Arctic Ocean, while seasonal ice forms and melts with polar seasons. Arctic ice cover also appears to play a critical role in global climate regulation.

Sea ice control the heat-moisture exchanges between ocean and atmosphere, and water salinity. It is acting as an insulation layer between the relatively warm ocean water from the cold polar atmosphere except where leads are formed in the ice allowing exchange of heat and water vapour from ocean to atmosphere in winter. The number of leads determines where and how much heat and water are lost to the atmosphere, which may affect local cloud coverage and precipitation.

Arctic sea ice extends to about 14 to 16 million square kilometres in late winter and on average approximately 7 million square kilometres remaining at summer's end. The sea ice cycle affects human activities and biological habitats. Arctic shipping, depending which route is going to follow might be possible only at summer period of low ice concentration. Many Arctic mammals, such as polar bears, seals, and walruses, depend on the sea ice for their habitat. These species hunt, feed, and breed on the ice. Studies indicate that declining sea ice is likely to decrease their numbers, perhaps substantially.

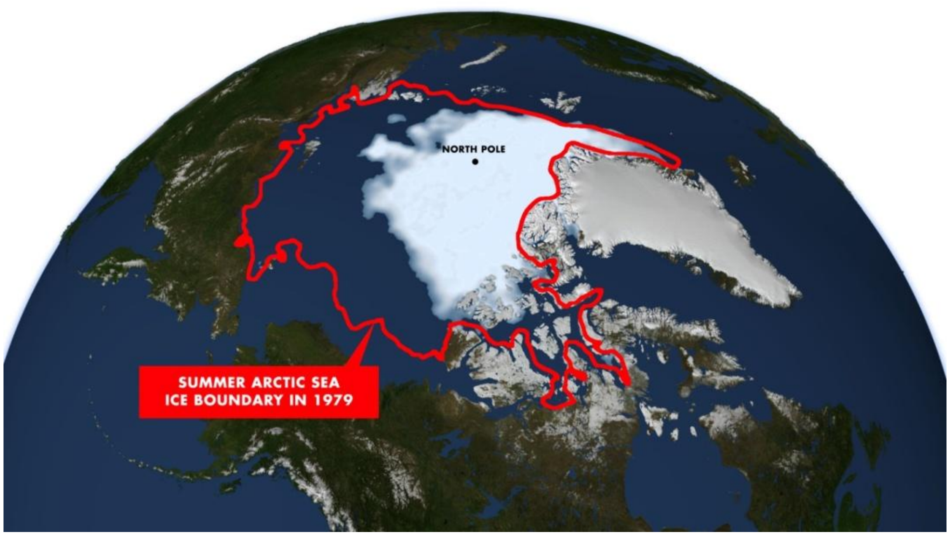

Figure 5 credit: NASA with 1979 boundary redrawn by NRDC (source: switchboard.nrdc.org, 2014)

The last 5 years, were particularly damaging to the ice cover. Arctic minimum have been decreased steadily down to only 4-6 million square kilometres with a further decrease trend forming. The main tools for monitoring the ice cover extent and collecting data about it are the Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager

(SSM/I) satellites and Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) sensor on NASA's Aqua satellite. Their data files spanning back to 1979, are publicly available, and supplemented by observations made by annual scientific missions in the region and crossing captain reports of coast guards and merchant ships.

The SMMR and SSM/I data sets, processed by National Snow and Ice Data Center (U.S.A.), reveal considerable regional, seasonal, and inter-annual variability in ice cover. Satellite data also reveal the winter Arctic ice's extent, steady decrease trend of about 3-4% per decade, since 1979.

The Arctic sea ice September minimum extent reached a new record low in 2012 of 3.41 million square kilometres, 44% below the 1981-2010 average, and 16% below the previous record in 2007. To place this observation in context, four records were set over the last 12 years, (2002, 2005, 2007, and 2012) and several other years saw near-records, particularly at 2008 and 2011. The following graph composed by NSIDC describes the sea ice extent in the region seasonally for the last six years compared to the historical average. This graph compares five-day averages for Arctic sea ice extent (area of ocean with ice concentration of at least 15 per cent) for the long-term mean (1981-2010), and the years 07, 11, 12, 15.

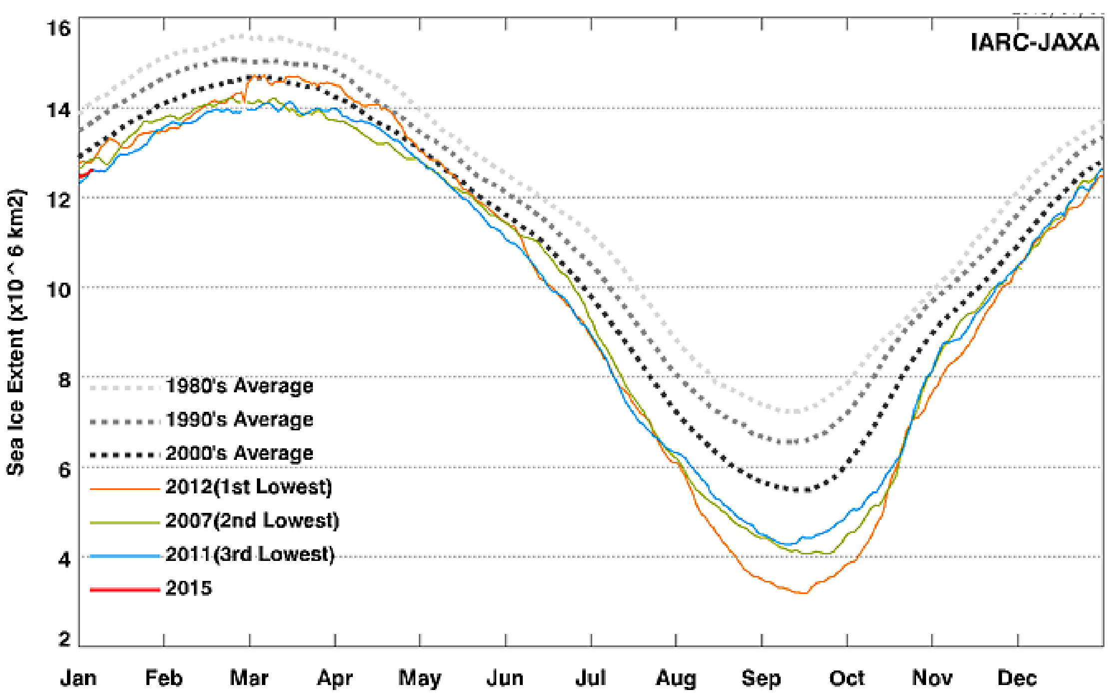

Figure 6: Arctic Ice coverage (source: National Snow and Ice Data Centre, University of Colorado, Boulder).

Integrally tied factor to the sea ice coverage is the sea ice thickness. Historical measurements by the Arctic and Antarctic Research Institute in St. Petersburg suggest 4.5 meters of multiyear ice in central Arctic Ocean. Observations of multiyear sea ice in the Arctic Ocean describe a rapid decline, while satellite data studies for winter conditions and summer minima describe a sharp decline in the presence of multiyear ice at least near the established navigational routes. Multiple more recent studies with data acquired with the usage of submarines cruises using upward looking sonars suggest a 32% decrease of that aspect.

Arctic Climate Impact Assessments, released by the Arctic Council and arctic countries relevant ministries, elaborate that the findings project a rather grim future when it is plausible an ice-free State for the Arctic sea as early as year 2040.

According the findings of Arctic Council's Arctic Marine Shipping Assessment 2009 Report "the fact, that there will always be an Arctic sea ice cover, has important implications for all future Arctic marine activity and for the development of ship standards and measures to enhance Arctic marine safety and environmental protection. The resulting sea ice conditions for future Arctic marine operations will be challenging and will require substantial monitoring and improved regional observations. This new Arctic Ocean of increasing marine access, potentially longer seasons of navigation and increasing ship traffic requires greater attention and stewardship by the Arctic states and all marine users."

1.3. Ecosystem

The Arctic ecosystem is a unique, complex food web that is fashioned by its distinctive plankton, animal species, and environmental factors. Capped with an ice and snow cover, total darkness during winter, gale force winds, and bitter cold, the Arctic Ocean is one of the most hostile and somehow captivating environments on Earth. Life here is forced to endure some of the greatest extremes, but despite these, the Arctic Ocean is full of life.

This section is providing important basic information about the health, wealth and protection status of this unique and important ecosystem.

1.3.1. Biodiversity

Biodiversity is the factor that describes the health, wealth and dynamics of any ecosystem on the globe. The latest Conservation of Arctic Flora and Fauna (CAFF) Arctic Biodiversity Assessment (ABA) study of 2013 is the most complete biodiversity report for the Arctic ecosystems to date. ABA 2013 reports per category of species:

Plants

The plant flora of the Arctic is relatively poor. Approximately 2,218 vascular plant species are recognized. Arctic vascular plants belong to 430 genera and 91 families, almost all belong to the flowering plants. Endemism is well developed, 106 species are endemic to the Arctic; almost all of them are forbs and grasses, while no endemic woody species exist. 20 Arctic endemic species are very rare, and as such are possibly threatened.

Fungi are one of the most species-rich groups of organisms in the Arctic and are not yet completly inventoried. The known number of fungal species in the Arctic is about 4.350, of which 2.600 are macro fungi, 1.750 are lichens and the rest are micro fungi. Total fungal-species richness in the Arctic may exceed 13.000, with most species being present throughout the Arctic, but only few endemic to the Arctic. Of the lichens, 143 species are listed as Arctic endemics, but it is likely that the major part will prove to be synonyms of other species. Fungi are pivotal in Arctic terrestrial food-webs. Mycorrhizal, saprotrophic and pathogenic fungi drive nutrient and energy cycling, and lichens are important for primary production, for example Reindeer lichens form dominant vegetation types in many areas and function as keystone species. The conservation status of Arctic fungi is predicted to scarcely be affected within the next decades but greatly changed over the long term.

Microorganisms

Until few years ago there were no studies looking for microorganisms in the Arctic, despite their profound significance they hold in all others ecosystems primary production. A recent survey of over 2,500 sequences originating from gene clone libraries identified 14 potential Arctic species. Because these sequences were retrieved from at least two independent studies is theorised that they are probably common and widespread in the Arctic Ocean. Among other protists with possible restricted distributions are several ciliates, dinoflagellates and Acantharia. Despite that the microorganism biodiversity in the Arctic is considered currently uncrown.

Animals

The list of Arctic animal life includes more than 250 species of marine fish and 127 freshwater fish species, of which 95% of the Arctic marine fish species have not been evaluated for threat status according to IUCN criteria, because of lack of resources.

5 primarily boreal and temperate amphibians (lizards), 67 terrestrial and 35 marine species of mammals with most found in the southern sub-Arctic zones where many occur as seasonal visitors from lower latitudes. Of them 19 terrestrial and 11 marine species are more or less confined to the Arctic. The mammals include 9 species of baleen whales, 13 species of toothed whales, and 11 species of seals including walrus. About 200 species of birds occur in marine and coastal areas in the Arctic.

About 70 species of seabirds; about 50 species of them are restricted to the sub-Arctic region in the southern parts of the Arctic area. From the 50 species of waterfowl catalogued (ducks, geese and swans), around 20 species breeding in the High and Low Arctic. A total of about 70 species of shorebirds or waders occur within the Arctic area, with almost 40 breeding in the high Arctic.

Upwards of 4,750 species of terrestrial and freshwater invertebrates living in the Arctic representing 27 classes of animals spread across at least 16 phyla. One class is endemic, the Micrognathozoa is known only from Greenland and the sub-Antarctic Crozet Island. The most multi membered groups are testate amoebae, rotifers, water bears, water fleas and copepods, ostracods, enchytraeid worms, eelworms, spiders, springtails, mites and insects. Their endemism is varied by the taxa. Highest is in mites 31% and lowest in stoneflies and cyclopoid copepods both at 0%.

Today, fewer non-native terrestrial plants have been recorded in the Arctic than in the more highly altered, invaded ecosystems of lower latitudes. Never the less, Nootka lupin has invaded almost all of Iceland and also occurs in SW Greenland. In Svalbard, is reported that 15% of the flora from a survey was non-native, from which nine species are actively reproducing. Also has found numerous non-native invertebrates, apparently brought in greenhouse soil. Similarly, over a dozen non-native plant species are already in both the Canadian low and high Arctic zones and many more occur in the sub-Arctic (Canadian Food Inspection Agency, 2008). In Arctic Alaska, 39 taxa of non-native plants, almost 7% of the species there, have already been reported and the rates of introduction and establishment in Alaska are accelerating. Among the known non-natives are several highly invasive grasses and clovers. This nitrogen fixing invaders have the potential to alter soil chemistry and has been shown to increase mortality of other plants. In the Alaskan sub-Arctic, over 75 invasive plant species have been recorded with a dozen of them ranked as ‘highly’ or ‘extremely’ invasive, all of which are well documented as being capable of dramatically altering ecosystem function.

A few well documented cases of species invasion exist: the American mink in Iceland and northern Scandinavia, Nootka lupin in Iceland and Pacific red king crab in the Barents Sea. In the case of the American mink, its introduction has been cited as a factor in population declines of ground nesting birds and small mammals, as well as the decline of the native European mink. Thirteen species of arctic mammals and 21 species of arctic birds are listed on the IUCN Red List of Threatened Species, not counting the 95% of fish species that are not evaluated because of funds shortages.

Category of 'Threatened'	Species	Latin name
Endangered	North Atlantic right whale	*Eubalaena glacialis*
	North Pacific right whale	*Eubalaena japonica*
	Blue whale	*Balaenoptera musculus*
	Fin whale	*Balaenoptera physalus*
	Sei whale	*Balaenoptera borealis*
	Sea otter	*Enhydra lutris*
Vulnerable	Sperm whale	*Physeter macrocephalus*
	Hooded seal	*Cystophora cristata*
	Northern fur seal	*Callorhinus ursinus*
	Polar bear	*Ursus maritimus*
Near Threatened	Beluga	*Delphinapterus leucas*
	Steller sea lion	*Eumetopias jubatus*
	Narwhal	*Monodon monoceros*

Category of 'Threatened'	Species	Latin name
Critically Endangered	Eskimo curlew[1]	*Numenius borealis*
	Kittlitz's murrelet	*Brachyramphus brevirostris*
	Spoon-billed sandpiper	*Eurynorhynchus pygmeus*
Endangered	Marbled murrelet	*Brachyramphus marmoratus*
	Red-breasted goose	*Branta ruficollis*
Vulnerable	Short-tailed albatross	*Phoebastria albatrus*
	Black-footed albatross	*Phoebastria nigripes*
	Pink-footed shearwater	*Puffinus creatopus*
	Red-legged kittiwake	*Rissa brevirostris*
	Lesser white-fronted goose	*Anser erythropus*
	Steller's eider	*Polysticta stelleri*
	Bristle-thighed curlew	*Numenius tahitiensis*
Near Threatened	Sooty shearwater	*Puffinus griseus*
	Ivory gull	*Pagophila eburnea*
	Laysan albatross	*Phoebastria immutabilis*
	Long-billed murrelet	*Brachyramphus perdix*
	Emperor goose	*Anser canagicus*
	Yellow-billed loon	*Gavia adamsii*
	Great snipe	*Gallinago media*
	Black-tailed godwit	*Limosa limosa*
	Buff-breasted sandpiper	*Tryngites subruficollis*

[1] Possibly extinct.

Figure 7 Threaten Arctic species IUCN red list (credit: ABA, 2013)

1.3.2. Protected areas

The Arctic ecosystems were protected by the extreme climate and the relative inaccessibility of the region that limited the human factor as a vehicle for species migration. The latest climatological changes and the increase of human activity, that they allow, are expected to be the main stressor for the regions biodiversity in the future.

The latest study commissioned to identify areas of heightened ecological importance, known as Arctic Marine Shipping Assessment II C, identified 16 Large Marine Ecosystems (LMEs) within the Arctic area. The result was the identification:

"…of about 97 areas of heightened ecological significance within the 16 Large Marine Ecosystems (LMEs) of the Arctic. The areas were identified primarily on the basis of their ecological importance to fish, birds and/or mammals, as these species are the most widely studied Arctic groups. The majority of areas identified are used by birds (85) and marine mammals (81), with a lower number used by fish (40, most of them spawning areas). About 70 areas are used both by birds and mammals, and only two of the areas identified are used only by fish. The areas of heightened ecological significance span to a total area of about 12 million square km, or more than half the total area of the Arctic ice-coverage. The areas are generally not homogenous but comprise subareas used by fish, birds or mammals. The subareas often overlap and are also often used by two or more species of birds or mammals, such as for breeding in seabird colonies or for staging by waterfowl and shorebirds. Thus, while the areas identified as being of heightened ecological significance cover a large total area, this is the aggregate area used over all seasons throughout the year. The area used at any one time is lower due to the strong seasonal pattern in the annual migratory cycles of fish, birds and mammals."

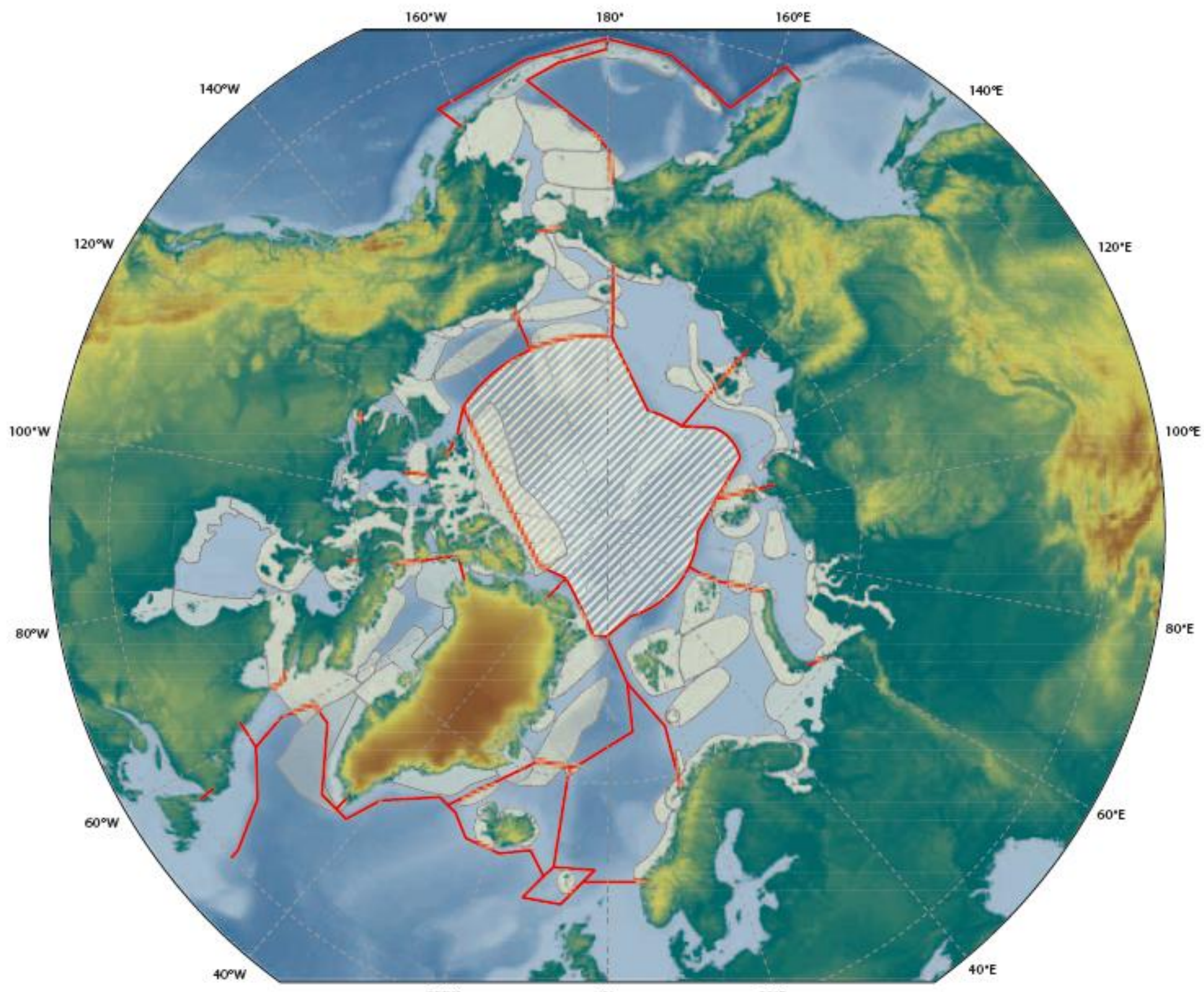

Figure 8: Arctic areas of heightened ecological significance as per (AMSA IIC, 2013)

Annex I include two technical lists that provide an overview of environmental impacts associated with Arctic marine shipping and the ecological use of areas by groups and/or species of fish, birds and mammals, and the associated sensitivity to shipping activities, (PAME, 2009).

1.4. History

The area's history is a timeline of the local native tribes and the exploration attempts by the Europeans. Since the beginning of time native tribes inhabited the area. These tribes were the first mariners of the region, looking for settlements and areas for food harvesting.

The following regional history review is a composition of descriptions of varius sourses such as: Polar Discovery .whoi.edu (2015), AMSA (2009), ACDIS (2009), Laineman M. and Nurminen J. (2009), Shelagh G. (2010).

1.4.1. European exploration

First European explorer is considered the astronomer/geographer/navigator Pytheas (Πυθέας), who in 325 B.C. reached Iceland and maybe even Greenland. 1.1 millennia later (850 A.D) Vikings were colonizing Iceland during their golden era's exploration of the globe that produced countless trading routs that helped Europe come out of her dark age. At 11th century Russian populations of White Sea continue the polar exploration.

Europeans refocus their interest to the area in late 15th century. The quest for a new route to reach China and India from the Atlantic via north is started and will last for five centuries. They will focus their efforts in two areas: The North Canadian coast and the North Russian coast. In the end they will explore and develop the North western Pass (NWP) and the North Eastern Pass (NEP) respectively.

In 1490 John Cabot proposed the existence of the NWP to the Orient, in 1497 he secures finance baking and a ship but he fails on his attempt to find it.

In Russia, in 1525 the diplomat Gerasimov introduces the idea of a possible seaway connecting the Atlantic and the Pacific, the NEP. For the next 350 years it becomes the only active Arctic exploration project. In 1648, the famous expedition led by Fedor Alekseev and Semyon Dezhnev, sailed east in the NEP from the mouth of Kolyma into the Pacific and rounded the Chukchi Peninsula, proving that no land connection could be located between Asia and North America. In 1725, another Russian explorer, the Dane Vitus Bering on the ship Sviatoy Gavriil made the same voyage in reverse starting Kamchatka and going into the strait that now bears his name. Bering also named the Diomede Islands, discovered and first described by Dezhnev.

Bering's explorations in 1725–30 were part of a larger plan, devised by Peter the Great and known as the Great Northern expedition. The Second Great Northern Expedition took place during 1735-42.

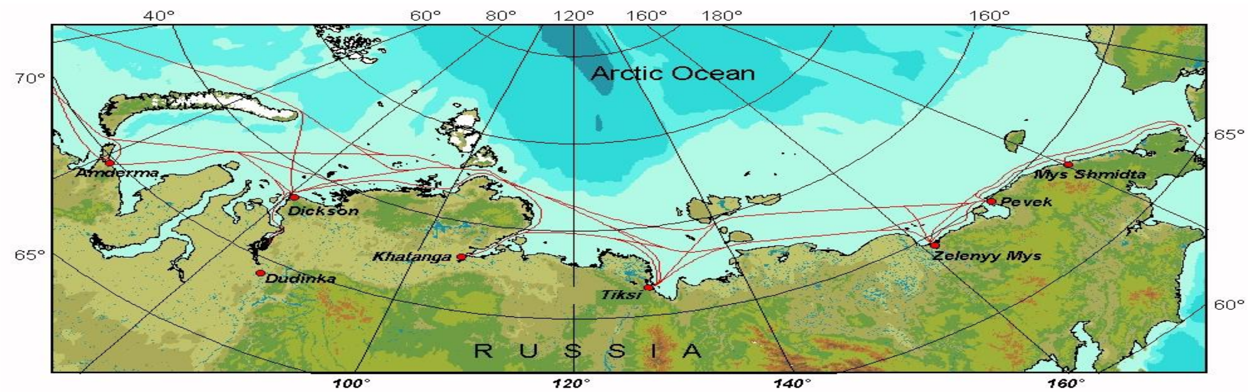

Figure 9: NEP/NSR (source: AMSA, 2009)

Famous explorer and captain of the Royal Navy James Cook attempt to find NWP in 1778, but he also fails. Royal Navy continues and explores the Canadian Arctic Archipelago during early 1800s. From now on the progress in both NWP and NEP project is feverish and simultaneous.

At the same time with Cook's voyage to NWP, the NEP is traversed by Baron Adolf Erik Nordenskjold of Sweden in 1878-79 aboard the Vega.

In 1845 the disappearance of John Franklin's ships Erebus and Terror triggers a massive rescue effort that has as result the complete exploration of the Archipelago in the following decade.

The on-going search for a NEP, using the Kara Sea route to Western Siberia becomes pivotal for Arctic marine transport. Two expeditions achieved transits of a substantial part of the NEP: Fridjof Nansen on the Fram (1893-1896) and Baron Eduard Toll on board Zarya (1900-1903).

In 1906 Norwegian explorer Roald Amundsen in his 47 ton sloop Gjoa became the first ship to complete the NWP. Amundsen took three years to complete the voyage, thanks to the invaluable help of the local Inuit population. Almost a decade later, (1918-1920), Amundsen on board the Maud, will make it the fourth ship ever to complete a transit of the NEP. As a result, Amundsen achieved the distinction of being the first person to circumnavigate the Arctic Ocean, since he had now linked up with the track of his voyage in the Gjoa.

By 1932 the Northern Sea Route, or NSR, stretching from the Kara Gate in the west to the Bering Strait in the east, is now established. During the first stage of its utilization, 1917-1932, the NSR becomes a community re-supply line, the main way for attempts at regional exploitation of resources such as furs, wood, fish, salt, coal, whaling and sealing.

In 1932, a Soviet expedition led by Otto Yulievich Schmidt will be the first to sail for the first time from Arkhangelsk to the Bering Strait without wintering en route.

The first one-season transit of NEP was not accomplished until 1934. Glavnoye Upravleniye Severnogo Morskogo Puti (GUSMP) - Chief Administration of the Northern Sea Route, mounted a successful attempt with the icebreaker Fedor Litke. Advanced Soviet navigational skills, technological capability and experience in ice navigation are now considered unrivalled and traffic in the Soviet Arctic continued to grow. From 1917-1934 only two ships will be lost. At the same time 178 round-trip voyages will be accomplished across the Kara Sea to import finished goods and export timber from Igarka region. In 1935 the Northern Sea Route was officially open and exploitation began. At the same time an effort is launched to organize the regular navigation coupled with the development of fleet and ports lasting till mid1950s. Major additions were made to the Arctic fleet, which carried 100,000 to 300,000 tons of cargo annually and employed 40-150 ships per year. In 1940, the German ship Komet venture into the NSR. It was an armed raider disguised as a merchant ship. It becomes the first foreign ship in more than 20 years to be granted passage, and it was the last foreign transit for another 50 years. When the Soviet Union entered the war in 1941, NSR became vital for transporting supplies into the country. During the war, 120 ships transported approximately 450,000 tons of relief supplies, which amounted to half the freight turnover for the NSR during this period.

The first complete transit of NWP was completed in 1942 by the Canadian ship St. Roch with Captain Henry Larsen. Then he made the return trip in only 86 days and became the first ship to transit the NWP in one season. Transits of the NWP after the St. Roch remained fairly rare until the 1970s. During that period's national securities was the driving force behind the navigation of the area. HMCS Labrador became the second ship making the transit of NWP, and the first armed Canadian ship. Three years later, the Labrador escorted the U.S. Coast Guard icebreakers Storis, Spar and Bramble on part of their NWP journey.

Figure 10: NWP (source: AMSA, 2009)

The eras raising tensions between the allies of the WWII escalated into the cold war which sparked the next large scale activity in the region. Cold War operations, especially the creation of the DEW line, will leave an ever expanding legacy of knowledge about Arctic shipping, spanning from design modifications, crew competency, and ship manoeuvrability in ice, infrastructure and governance concerns.

In 1953 CANSR became a department under the Ministry of Merchant Marine in Moscow and for next 17 years the infrastructure will be improving to provide the capability for both summer and autumn shipping, transforming NSR into a regular operating transportation line.

In 1954, the Distant Early Warning (DEW) Line began to be built. It was a chain of 63 communication and radar stations, spanning 3,000 miles, from Alaska to Baffin Island, designed to detect Soviet bombers. It was located entirely within the Arctic Circle, with 42 of the 63 sites situated on Canadian territory. During its construction (1954 to 1957) more than 300 ships sailed the Arctic waters carrying more than 300,000 tons of cargo. This initiative created access into the Canadian Arctic through three major sealifts: the West Coast Sea Lift, the East Coast Sea Lift and the Inland Sea Lift. Most of the ships lacked ice-capability, which often resulted in lost propeller blades and hull breaching. The American Military Sea Transportation Service responded with retrofitting its ships with nickel-aluminium-bronze alloy propeller or steel sheathing, but more importantly designed and constructed ships specifically for operation in the Arctic environment.

Because of the American interest in the North, Canada was driven to acquire icebreakers and develop superior navigational capability in the Arctic. That effort materialized as CGS d'Iberville (1952) and HMCS Labrador (1954).

In 1957, the U.S. Coast Guard sent three icebreakers on a complete transit through NWP with partial Canadian icebreaker support, in a successful attempt to investigate whether ships could escape to the east when iced-in on the west.

In 1959, the Soviet Union launched the world's first nuclear powered surface ship. Icebreaker Lenin is extremely significant as it expanded the range of travel in the isolated region.

In 1968 a discovery of a major new oil field on Alaska's North Slope at Prudhoe Bay signalled the start of a new era of transportation technology and a shift to the interests in the arctic region from military to economic development. Two of the companies involved, ARCO and BP, intended to build a pipeline from Alaska's Brooks Range to an ice free port in Valdez in order to deliver the crude for tanker shipment south. But because of the ships "flexibility credits" and the possibility of sipping crude direct to both U.S. west and east coasts, Humble Oil and Refining (now ExxonMobil) persuaded her parent company Standard Oil of New Jersey, to make a study of icebreaking tankers. In 1969, four shipyards, an international team of maritime experts and the three major oil companies pitted their technical, creative and financial resources to attain the goal of taking a tanker through the infamous NWP. The SS Manhattan received an eight months long, extensive refit to be converted into an icebreaking tanker. The task had split among four shipyards, cost $US28 million. The SS Manhattan set sail with 126 persons on board and no cargo but a symbolic barrel of oil, the tanks was filled with water to simulate loading. It became the first merchant ship to complete the NWP voyage. Of key importance were the escorting icebreakers accompanying the Manhattan, especially the Canadian icebreakers John A. MacDonald, later the Louis S. and St. Laurent. In this voyage the Manhattan was successful as a large model test ship, as the ship broke thicker ice than any ship in history.

The trip had far reaching international effects. A model of the Manhattan was built and tested in Wartsilla's new ice model basin in Finland. Built specifically to support the Manhattan endeavour, the basin started the ice technology exchange between Soviet and Finnish scientists. After the trip was completed, in Canada triggered a discussion on sovereignty and eventually the passage of the Arctic Waters Pollution Prevention Act (AWPPA). Information collected from the two Manhattan Arctic voyages, defined future generations of icebreaker ship designs.

In 1970, CANSR transform into the Administration of the Northern Sea Route (ANSR) and the emphasis of its operations became the year-round trafficability of NSR. By the 1978-79, the western end of the NSR achieved year-round navigation with ships sailing between Murmansk and Dudinka on a regular basis.

In 1977 another landmark voyage of Russian Arctic marine transport history is taking place. The Arktika sails for the first time to the geographic North Pole.

In 1978, the ship Sibir is the first to complete a high latitude passage by surface. By the mid-80s, the total volume of traffic passages through the NSR amounted to 6.6 million tons annually.

In 1978 M/V Arctic is build and routed in the Canadian Great Lakes. It will become one of most important research and development ships. During the ships more that over 30 year service it will be fitted with the latest sensors for many projects to provide valuable ship performance data on ship design, hull strength and trafficability. As a permanent testing platform it will become a treasure trove of continuous data of critical importance to future generations of Arctic transportation.

In 1991, the NSR is formally opened to non-Russian ships in the, only a few months before the Soviet Union collapse. The new era brought new developments for Arctic marine transport:

- ANSR becomes the NSR Administration.

- The commissioning of the International Northern Sea Route Programme is being founded.
- The Non-commercial Partnership for the Cooperation of the Northern Sea Route Usages is formed.
- Leaps in improving fleet and port infrastructure along NSR.

Figure 11: Ports served by NSR. (sourse: Cryopolitics.com, 2015)

The last decades development of the ice coverage extend and the cumulative knowledge of all the above mentioned pioneers are about to usher the region in new changes. The current accessibility of the region is bound to improve further posing to make the NSR and NWP significant global merchant routes.

1.4.2. Native human history and ethnography

The Arctic Natives history is long and complex and with largely unknown specifics, nevertheless cannot be of any less importance since they were the ones that mastered the Arctic first and tought the Europeans how to do it afterwards. It is divided in 3 periods, although it must be held in mind that this is a bit inaccurate. The section is quoting cabrillo.edu (2010) "*The Native People of North America"* article and Shelagh (2010).

The Paleo-Indian Period**:** (more than 10000 years ago). Very little is known about this period. Most of Alaska was ice free during the last Ice Age and connected to Siberia by the now-submerged land bridge called Beringia. Undoubtedly, many sites of this period were buried by rising sea levels at the end of the Ice Age, perhaps many of them in places where populations exploited coastal and marine resources and lived in somewhat permanent base camps.

The Archaic Period**:** (from 10000 years ago to contact with the Europeans age). Up until about 10.000 years ago, the region was occupied by populations whose ultimate cultural roots lay in Siberia. Their territorial expansion and tribal scattering across the region, created a greater cultural diversity and hunter-gatherer cultures began to flourish. These cultures are considered of Paleo-Arctic tradition, a shadowy entity composed of a patchwork of localised cultural traditions that flourished for at least 3000 years. This tradition is known mainly from stone artefacts, the most distinctive of which are tiny blades (usually less than 6.5 centimetres long) and the small wedge-shaped cores for making them.

Exactly who were the carriers of the Pale-Arctic tradition is open to question. Some anthropologists believe that the late Paleo-Indian period persons who remained in the north-western Arctic after others had journeyed southward, eastward, or both, developed a generalized early Pale-Arctic economy, and that these folks were the ancestors of the Na-Dene. Others suggest that at around 12000-14000 years ago, after several earlier migrations, ancestral Na-Dene moved across the land bridge, pursuing thin-skinned animals like the caribou. Over time, they spread south and west to Kodiak Island, to the Pacific Northwest Coast, far into the interior. Later, some of them split off and moved southward to become the modern-day Navajos and Apaches. At some later time (anywhere from 10000-7000 years ago), a second migration brought the maritime-oriented ancestors of the Aleuts and Eskimos to Alaska who replaced earlier Pale-Arctic communities in the Arctic culture area and have occupied that territory ever since.

The Western Arctic**:** By about 7000 years ago sea mammal hunting was established in the western Arctic and as a result early Eskimos were able to inhabit the unoccupied northern portion of the Arctic, by at least 4000 years ago. Some of the communities stayed in the western Arctic, developed into the archaeological culture called "Norton", oriented toward both maritime and inland resources. Around 2700 years ago the "Norton" culture along the Bering Strait in western Alaska evolved into the Thule, a specialized maritime adapted culture. About 1.700 years later, other Thule populations split off from the Western Thule, expanded eastward, replaced an older archaeological culture called "Dorset", and eventually became the Eastern Eskimo or Inuit.

The Eastern Arctic**:** Humans had begun moving into the eastern Arctic by at least 4000 years ago. The first immigrants lived in highly mobile bands composed of certainly less than a dozen persons, and hunted musk ox and other animals. Several thousand years later, the region was abandoned again due to the very cold climate conditions. The region was repopulated around 2500 years ago by the so-called “Dorset” civilisation, which lived in large villages, hunted seal with harpoons, and created some of the most spectacular art in the Arctic. About millennia ago, the Dorset "disappeared," perhaps due to a warming of the climate which decreased seal populations. They were replaced by an expansion of Thule from the western Arctic. Thule were better adapted to the Arctic than the Dorset, they hunted a broader range of animals, had a more flexible socio-political organization, and had a generally more technologically efficient culture which included dogsleds, bows and arrows, and boats.

The European Contact Period**:** Sometime shortly after 1000 A.C., the Inuit of the eastern Arctic became the first Native Americans to contact Europeans, encountering the Norse while moving west from Iceland to Greenland. Contacts were assumed to be sporadic and brief, although that claim can’t be verified, because the Norse sagas mention the natives of Greenland but say next to nothing about them.

The first sustained contact between the eastern Arctic populations and Europeans occurred in 1576 when some Inuit were captured and taken to Europe as curiosities. Martin Frobisher, an Englishman backed by private investors, set sail for the North American Arctic in search of the elusive NWP. In June, Frobisher found his way to the southern part of Baffin Island, where he was greeted by Inuit in their summer camp on Niountelik Island. Frobisher erected a cairn to claim England's possession of the area and opened trade with a group of Inukt who also appeared. When the trading was finished, he decided to “acquire” interpreters for his expedition and after a brief skirmish, captured one Inuit.

In the western Arctic, contact with Europeans began in 1732 when a Russian naval expedition landed in Alaska. Nine years later, a second Russian naval expedition, under Vitus Bering, claimed it for Russia. Over the next three decades the Russians repeatedly visited the Aleutian Islands, the coasts of south-eastern Alaska, and eventually reached northern California. The Russians were not seeking land to settle, but the fur of sea otters and seals. In order to secure the precious commodity harassment, ransoming tactics and population control raids were employed, similar to US tactics during the conquest of the West and what Belgians used in Central Africa.

In the 1840s, American whalers began visiting the Arctic, intensively hunted whale, the result was that by about 1900 local whale populations were depleted. Furthermore, the whaling ships often stopped at coastal native villages, where the sailors infected the natives with venereal and other communicable diseases resulting to complete wipe out of populations-tribes. They also distributed rum and made rifles available, which had a profound effect on the Eskimo culture, both by increasing their reliance on westerners for new guns (the Eskimo lacked the technology to repair guns) and ammunition and by depleting game populations.

1.4.3. Native culture and tribes

As mentioned it would be inaccurate to view Native history simply as before and after the arrival of the Europeans. The traditions of the natives themselves, as well as the findings of archaeologists, show that the populations which are now called indigenous had already migrated extensively themselves during the previous few thousand years. Some Inuit reached Greenland from Canada about 1000 years ago, not long before the Vikings reached there from Europe. Their society existed for nearly 500 years but probably died out due to a combination of climate change, subsistence failure and lack of culture contact. The Arctic hunters did adapt to colder climate and became the ancestors of the modern Greenlandic population. In the Asian North, to take another example, the largest northern tribe are the Sakha, who number 382000. They speak a language related to Turkish and migrated from central Asia into the Lena valley during the middle ages. When they arrived, they found the valley already occupied by the Eveny, pushed them out and up into the mountains where they now herd reindeer. But even the Eveny were not originally residents of the North and had earlier migrated from northern China, they are related to the Manchu who until the beginning of the 20th century were the rulers of the Chinese empire.

The Inuit, Yuit, Inupiat and Kalaalit mainly live along much of the North American Arctic coastline. Their land is unproductive and they live from the sea by fishing and by hunting seals and whales, for them and their life style, the sea links islands rather than divides them. Inuit travel by kayak and other forms of boat in summer while in winter they can move quickly by dog sledge or snow-scooter over the frozen surface of the sea.

The Russian North contains three tribes, the Komi, the Karelians and the Sakha. Each of them has their administration and territory, though in fact they are generally outnumbered there by Russians or other European settlers, such as Ukrainians. At the same time 26 smaller groups, spread along the River Ob in western Siberia, who belong to several language families and number from a few hundred to a few thousand each. Their traditional economy was based on fishing. Further to the north, around the mouth of the Ob, live the Nenets who herd reindeer in the region where the forest meets the tundra. The Eveny, who also live mainly by herding reindeer, live much further east towards the Pacific.

A distinctive and unusual group, the Saami, live in the north of Norway, Sweden, Finland and Russia. They number around 35000 and have probably lived there for 4000 years. The Saami on the coast were sea fishermen while those in the interior were reindeer herders or freshwater fishermen. The Saami have a long history of close contacts with the Scandinavian population and only about 10% are now involved in reindeer herding.

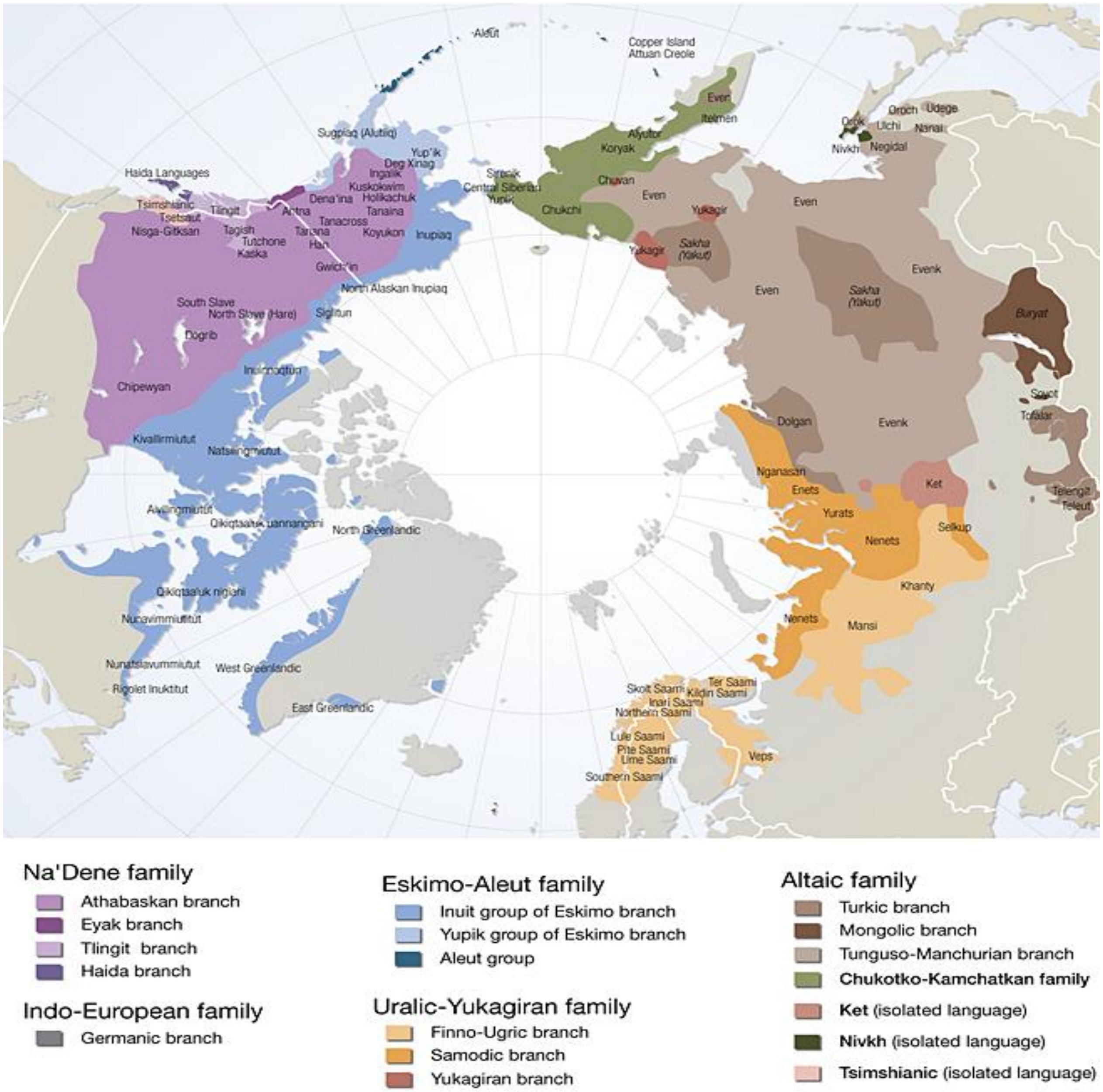

Figure 12: Demography of indigenous population of the Arctic based on linguistic groups GRID Arendal and Hugo Ahlenius, Nordpil.

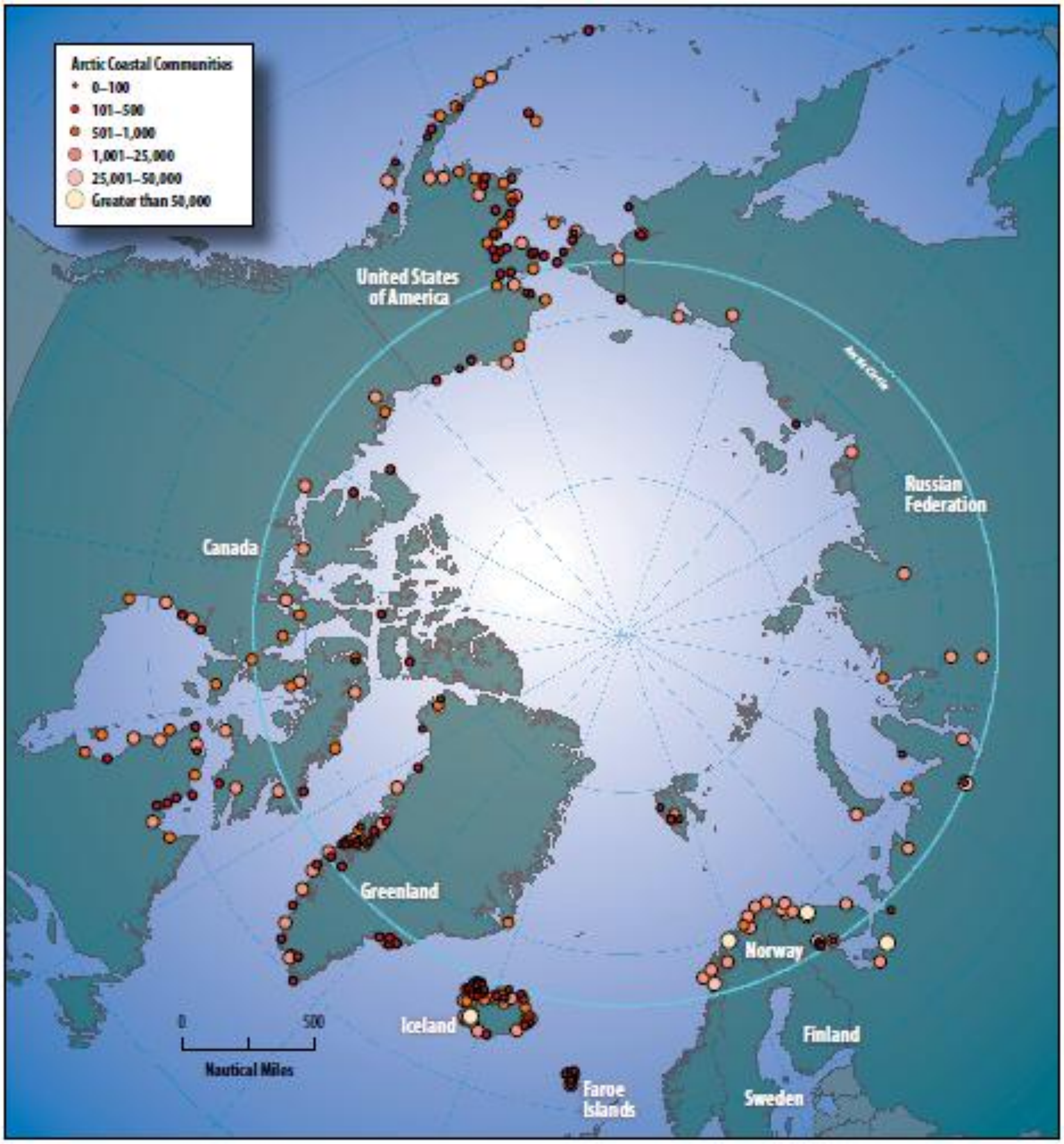

Figure 13: Circumpolar human centres and density (source: AMSA, 2009).

The Arctic culture is considered of global importance archeologically since it is defined by the migration of humans to the North East Asia and from there to North America during the last ice age. Modern indigenous population still tries to hold on to their ancestral tradition of living with the nature. Despite the efforts made to understand their culture and history the information that we currently have is incomplete and largely fragmented. Their land is distributed across several states or legal jurisdictions. That alone prevented a resent attempt by Arctic Council to compile a comprehensive catalogue of important archaeological and cultural areas of the Arctic region.

1.5. Shipping and governance

The contemporary rush to the Arctic re ignited cross-boundary tensions in the region frozen since the Cold War era, till recently there was a race to establish maritime Exclusive Economic Zones (EEZ) and continental shelve boundaries in the Arctic. Antagonistic tensions run high between Canada, Norway and Russia in an effort to secure valuable mineral deposits in their reach. Last year's bilateral agreements defuse the situation, establishing the current national borders to all stakeholders' satisfaction. That does not mean that local geopolitical and geostrategic issues are solved. Last summer Russia, stage a major return of military presence in the area, responding to strategic pressure by NATO in other regions of the globe, which in turn respond by staging the largest military training manoeuvres since the Cold War.

That sort overview of underlining antagonism, as accurate it is, it would have been unfair if considered in isolation. The last 35 years saw a very productive international cooperation about the regional issues. In 1989 the Arctic countries developed the Arctic Environmental Protection Strategy, which gave birth to Protection of the Arctic Marine Environment (PAME) working group. In 1996 the Arctic Council was established as an intergovernmental forum for addressing the common concerns and challenges faced by governments and indigenous communities of the Arctic.

Concerning legally binding norms, the 1982 UN Convention on the Law of the Sea (UNCLOS) rain supreme in the affairs of the region since it is basically a land locked Ocean. All Arctic states have ratified it except the United States. UNCLOS also dictate the protection and preservation of the marine environment regime for the region, Article 194 of the Convention dictates that all states involved in Arctic shipping share the responsibility for the safety of navigation and environmental protection of the region. The rules developed for accident prevention are following the principle of free use and exclusivity of flag state jurisdiction on the high seas, since it is mutually beneficial to agree on minimum standards, to exist for all parts of the sea.

Although governments bare the prime responsibility, important contributions have been made by more private stakeholders such as classification societies, NGOs, and others. The leading organization concerned with maritime safety, that holds a prominent role in the development of such standards is: the International Maritime Organization (IMO). IMO has developed key legal instruments, the numerous Conventions that follow and interpret UNCLOS, setting the standard baseline for all aspects of ship construction, operation, crew and passenger safety, and their acceptable impact on social resources such as the environment.

IMO also has the ability to “consider and make recommendations upon matters” within the organizations scope, direct result of that ability are the various best practice guidelines, codes, recommendations and resolutions published, some of which has become mandatory complements to pre-existing Conventions. Prominent paradigm the International Safety Management Code for the Safe Operation of Ships and Pollution Prevention (ISM Code) that became mandatory under Chapter IX of the SOLAS Convention

The condition of the legal framework surrounding shipping activities in the Arctic ice infested waters can be described as complicated. To begin with, UNCLOS is setting a fairly complicated background of state power jurisdiction and state rights for the seas around the globe. The in detail explanation of the situation is out of the scope of this paper, but a general overview can be obtained in the following image 14. Anyone can see the overlap of continental self and High Seas legal zones.

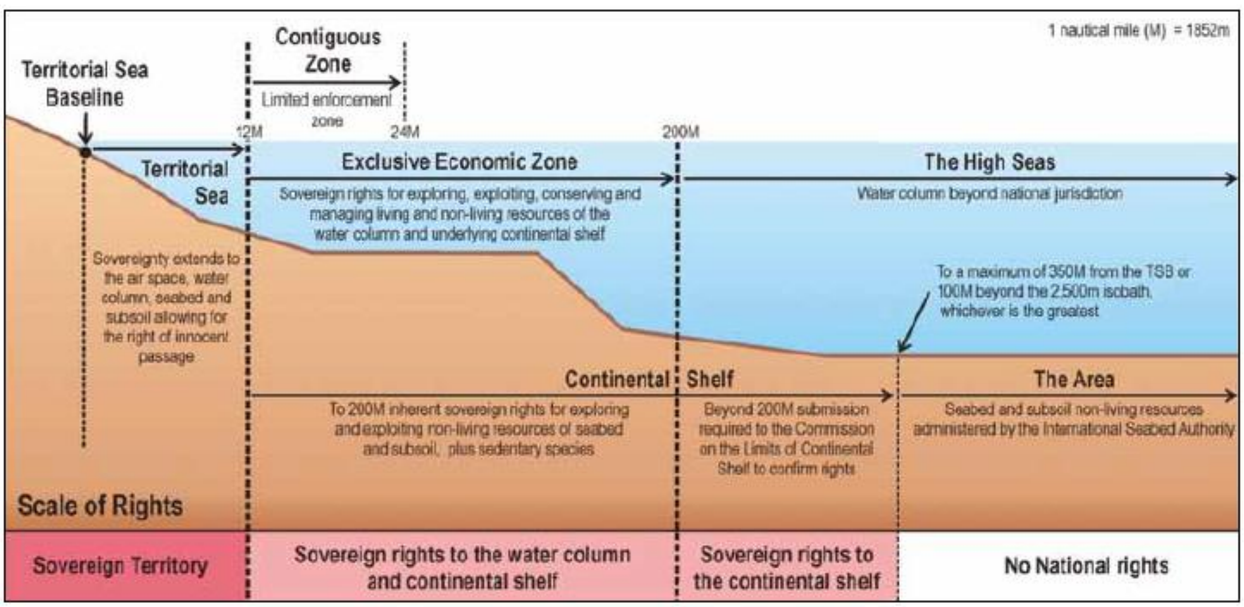

Figure 14: Illustration of maritime zones (for illustrative purposes only). (Source: unclosuk.org, 2015)

Another such paradigm is the “enclosed waters” definition in archipelagic environment, which propagate the power of the costal state. Canada consider the NWP part going through the Canadian archipelago as territorial water when US for her part and Russia for her NSR consider them under special scope for which developed specific set of laws.

The situation becomes instantly most complicated when we focus on polar waters that are ice covered. UNCLOS’s infamous Article 234, allow the coastal states to enforce their own regulations about pollution control at ice covered waters beyond their territorial water limit. The definition of ice covered waters as described in both Article 234 and SOLAS Section G-3.2 paragraph 2 is including ice concentrations of 1/10 coverage or greater which pose a structural risk to ships, but it does not exist an objective method to determine the precise level of ice coverage and thus the extent of costal state laws applicability, is still argued in legal forums, as it is a matter of interpretation. Further complicating the matter is the difference between the two conventions in the time criterion of the ice coverage, UNCLOS demand to be present most of the year but SOLAS makes no temporal demands. A further escalation on the above complication is the addition of a "marine strait" environment that in contrast limits locally the enforcement of costal state rules.

Another issue is the flag state and port state law jurisdiction on high seas especially when the state does not have laws concerning navigation in Arctic waters. Ice covered waters provides unique challenges to the navigators and the 2002 IMO Guidelines for Ships Operating in Arctic Ice-covered Waters (Arctic Guidelines) only provide internationally accepted recommendatory guidelines.

Labour law and quality standards also do not have a specific section for Arctic-Antarctic zones despite that there can be characterized as hazardous. The gap is somewhat covered by the Arctic Guidelines but their voluntary nature and the lack of proper training standards for ice navigation are sustaining the problem. The latest mandatory under SOLAS Polar Code have made most of the Arctic Guidelines obligatory rules and in some cases take a step forward by establishing training standards and certification process.

Despite the scientific and communal recognition of the environmental sensitivity of the area it has not received a special treatment for marine pollutant discharges as Antarctica did. Other agreements are or can be in place in order to regulate this aspect (like BWM or 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation, OPRC) but are case by case and complicate the situations further despite their individual importance. The fresh Polar Code (November 2014 draft version) it makes some provisions in that matter but it is argued that it is too week, as it is more lenient than the allowances for Mediterranean Sea.

Port authorities are having different standards for which they inspect for compliance upon ship arrival or departure; US use Paris MOU, Canada the Arctic Waters Pollution Prevention Act and Russian Federation the NSR law. This have not change since the AMSA, 2009 report, despite that the Polar Code added some common demands.

AMSA 2009 also reports that Private Maritime Law framework about salvage is as of the rest of the world. Special rules are used by preference and by case by the contracting parties and in the same spirit, the issue of marine insurance on the other hand is a bit more fogy, although most of the risks associated with shipping through the area are well known and understood by insurers and assureds alike, the risks associated with polar navigation are still not fully known or understood. With the exception of the NSR, the Arctic is perceived as a marine frontier, making it non uniform and expensive.

According of the same report, (AMSA, 2009), liability and compensation rules are a patchwork like in the rest of the globe. The issue is that they do not address occurrences in the high seas. Correction attempts were made, for global usage, generally covering oil products and dangerous chemical cases. Seven Arctic states went a step further with adopting 1992 Civil Liability and Fund conventions but US went its separate way.

From the above very short analysis two important factors are immediately recognized:

1. The combination of territorial waters and adjacent exclusive economic zones of the coastal states form a continuous chain of legal zones that fully encircle the Arctic Ocean, bar an enclave of High Seas in the high Arctic.
2. National regulations vary so wildly that a ship navigating within the exclusive economic zones of the Arctic States, face so differing technical requirements that it might be impossible for it to comply with all laws to which it might become subject during the course of a single voyage.

In the last year massive efforts by the IMO and Arctic Council are driving home two mutually completing texts, the Polar Code and Arctic tourism best practices. Both of them are fixing, to some extent, the gaps and omissions in the rules that mention above. Final texts fore both are expected to be introduced in the spring of 2015. Wide criticism on both texts provisions is currently in full effect and extent. Polar code is considered too lenient towards allowed emissions and damping of fluids, at least in comparison to Antarctica standards and some (Canadian) national laws. Best practices text is criticised about lack of enforcement policies and voluntary base of its nature.

1982 United Nations Convention on the Law of the Sea (UNCLOS), IMO international rules and regulation issued by the coastal states create a bureaucratic maze, of jurisdiction claims. Different interpretation of UNCLOS rulings and the voluntary nature of IMO code are creating issues among the countries pursuing their interests.

2. Arctic Tourism

The Western history, since 1576, is littered with chapters of exploration and imperial expansion in the Arctic that are filled with danger and ending in tragedy. Expeditions in this cold, harsh, remote place met with hardship, broken ships and loss of life. By 1800s explores were public heroes and news medias of the eras were covering the drama of their polar exploits. Despite the bleak notoriety, of the region, it started to attract thrill seeking tourist since the early 1800s and that stream is growing steadily for more than 200 years now.

The birth of tourism is as a result of the 19th century's Industrial revolution social impacts. Personal wealth proliferated, public education improved and leisure time for industrial workers introduced. New technologies, like the steam engine and the telegraph, improved man's access to remote parts of the globe. One of the results that change brought was that more and more persons were able to afford traveling for pleasure. The improvements of passenger capacities of ships and trains make their fairs progressively more affordable and tourism became an activity for the masses and not just for the privileged.

But the end of that century line ship and railroad companies had the capacity to move enormous numbers of individuals, never seen before. Competition cut costs and prices, progressively and the desire to offer new options drove the expansion of transport networks (even in the Arctic); all in the name of market expansion and success in competition.

The first commercial tourist steam ship was first routed in Norway in 1850. The next 30 years brought to Arctic marine tourism travels destinations such as: Norway's fjords and North Cape, transits to Spitsbergen, Alaska's Glacier Bay and the gold rush sites as far north as Homer, riverboat cruises in the Canadian Yukon, and cruises to Greenland, Baffin Bay and Iceland.

The novelty of big steamships and their luxury, with the little known or recently discovered glaciers, bays, wildlife and indigenous communities, attracted groups of adventurous, curious tourist led by explorers and naturalists.

Shipboard activities were gravitating towards grand meals, orchestral concerts, beauty parlours and barbershops, photography studios and lectures presented within library settings.

The mixture of exploration and luxury made those early cruises a commercial success and cruise ship companies continued to operate and expand their itineraries throughout those and other Arctic regions until the WWII. The same business model continues to attract clients till our days.

Arctic tourism became a flourishing commercial activity by early 20th century. Independent travellers pursuing a variety of adventurous recreation activities in marine and land environments were now accommodated, as well as groups touring natural, wildlife, historical and cultural attractions. Their extensive promotion was made by popular press, and specialized tourist guidebooks and periodicals such as Harper's Weekly, The Century Magazine and the National Geographic Society Magazine.

Arctic governments and private companies immediately noticed the revenue created by the booming Arctic tourism industry. More jobs positions became available, average personal income improved and more and more funds for infrastructure became available. Industries such as hydraulic mining, rampant timber harvesting, and the exploitive commercial fishing and whaling practices of the 19th and early 20th centuries, found for the first time a viable alternative.

2.1. Current traffic information and developing trends

Activity data is difficult to be found as little research activity is focusing on passenger shipping activities in the Arctic and no mandatory traffic monitoring system for all ships is in place. Also it is difficult to separate sub-Arctic to Arctic tourism and both of them from general tourism in the Arctic countries, were in many cases do not apply such refinement to their data.

According to recent reports from CLIA, AECO and tourism authorities the number of tourists that are visiting the Arctic waters reached their peak at 2008-2010 periods. Since then its declining slowly and in the last year it seem to stabilize. The number of ships cleared for operations is reduced also but stable now and the ships are bigger now. The general trend is one of slow but steady expansion. Regionally we have the following.

2.1.1. Arctic Canada

The Cruise Tourism in Arctic Canada study (CTAC) of 2012 describe the current trend in the region as: "...grew dramatically from 1984 when the industry first started, to 2008 when there were a record 26 cruises. The numbers now appear to be stabilizing at about 22 to 25 cruises each year. Minor fluctuations from year to year have occurred, likely due to a variety of reasons such as the 2009 recession, ship inspection failures, business mergers, and changing demand. Longer term factors that might limit additional growth include a lack of ice strengthened ship available for tourism purposes, industry re-structuring, and complex regulatory processes."

The CTAC study recognized a new and very important development. Private pleasure craft are now traveling for t0urism purposes in the Canadian Arctic with rapidly increasing frequency. The increase is about 300% in the last 15 years.

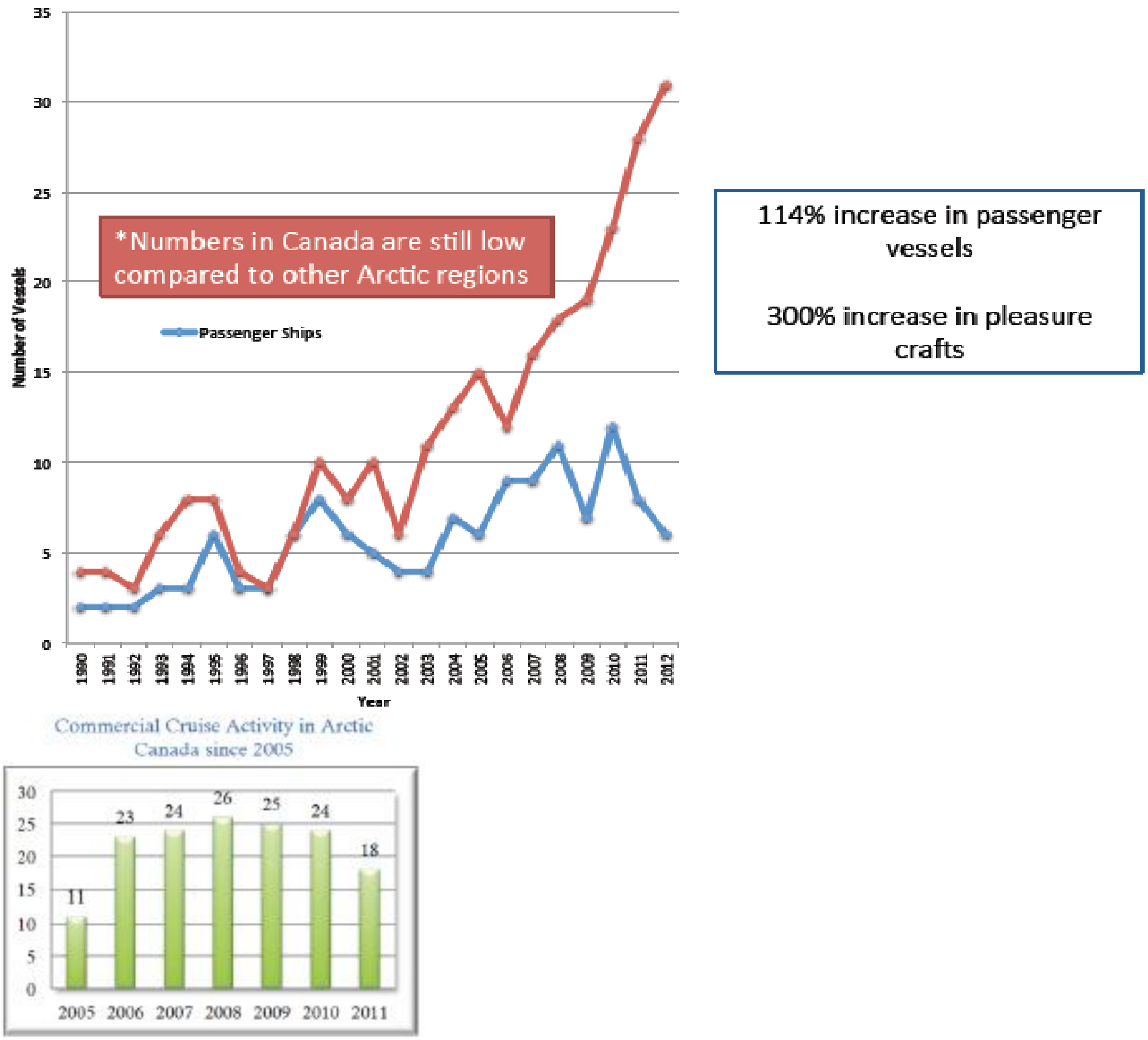

Figure 15: Canadian Arctic traffic information (source: AMTP, 2014)

2.1.2. U.S. Arctic

The U.S. Government Accountability Office reports in the "MARITIME INFRASTRUCTURE Key Issues Related to Commercial Activity in the U.S. Arctic over the next decade", (March 2014), that:

"A handful of cruises each year sail in the U.S. Arctic, and the number is expected to remain relatively stable through the next 10 years. Cruise ships that sail above the Bering Strait in the U.S. Arctic are a niche segment of the adventure cruise market. According to representatives from an Alaska cruise association, only one of its members currently uses the Northwest Passage once or twice per year with small cruise ships that carry fewer than 200 passengers. By comparison, mainstream cruise ships, which operate in southeast Alaska, can carry more than

1,000 passengers each. Cruise industry representatives we spoke with expect cruise tourism in the Northwest Passage to remain limited to adventure cruises for the next 10 to 15 years The representatives did not believe that mainstream cruise companies would offer U.S. Arctic tours in the foreseeable future or that additional charting or mapping, icebreakers, or search and rescue capabilities in the Arctic would increase cruise traffic in the Northwest Passage. According to representatives from a cruise association, the primary reason for the limited number of Arctic cruises is a lack of demand from the mainstream cruise consumer base. They noted that approximately 10 days are required to sail the long distances in the U.S. Arctic, often with no variation in scenery and no points of interest for which to disembark."

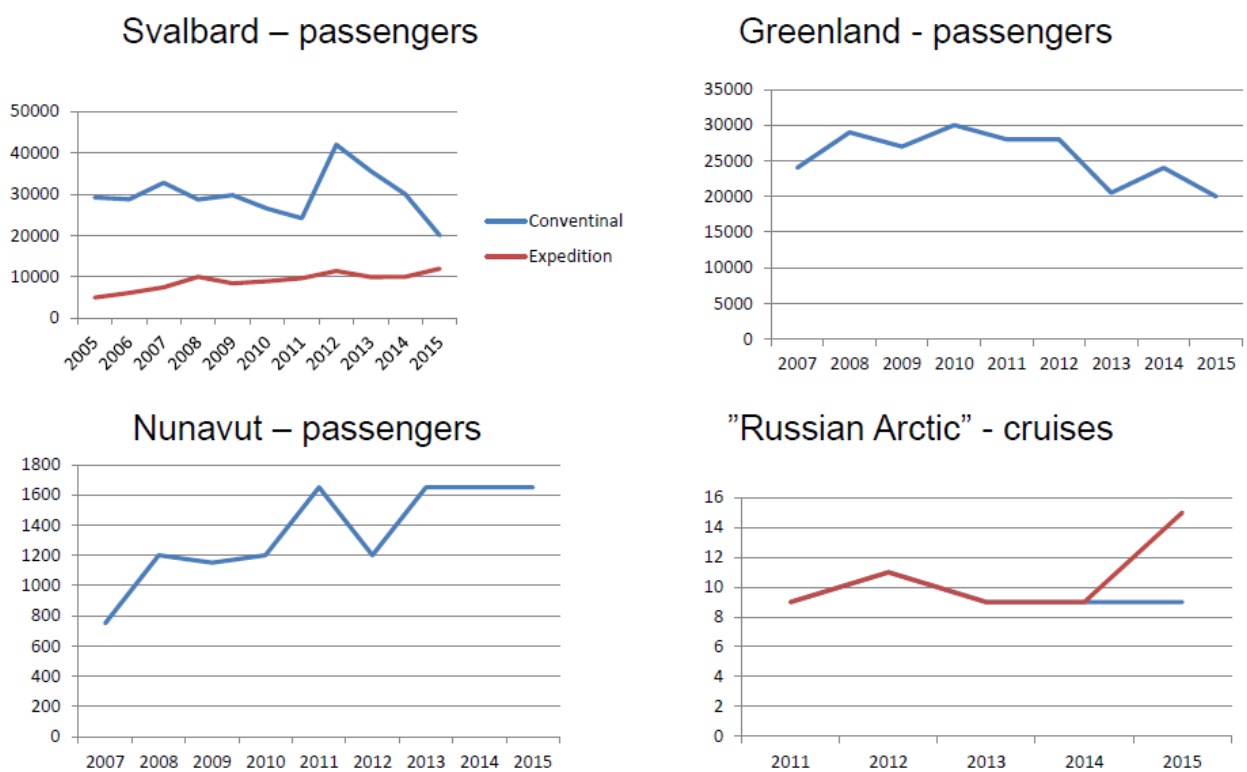

Figure 16: European Arctic cruise traffic information (source: AMTP, 2014)

2.1.3. Russian Arctic

No information is provided, about the current ship traffic related to tourism in Russian Arctic or their passengers per year. It is well known that at least several trips per year are made to the North Pole by Russian nuclear powered icebreakers (expedition cruises) with random number of passengers that indirect sources report that tend to increase. In addition a recent interest is developed to create a market for cruises launched from Russian ports in the White Sea.

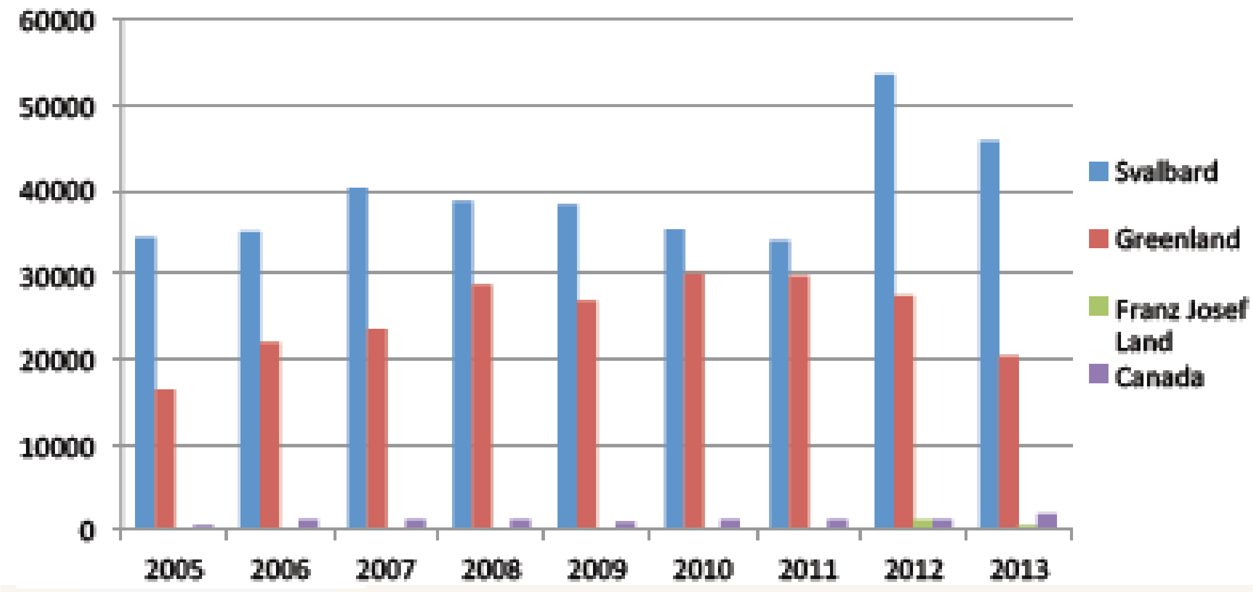

Figure 17: Total ship based tourists in Svalbard, Greenland, Franz Josef Land and Canada (source: AMTP, 2014)

2.1.4. European Arctic and Greenland

Arctic Expedition Cruise Operators (AECO) reports, that the conventional commercial cruise industry has been relatively stable in the European Arctic for the past decade with some signs of a decline in recent years. Current data also suggest similar trends for expedition cruises. The declining availability of expedition sized ships for hire was cited as a primary reason for this trend.

AECO is based in Denmark, their member base is slowly expanding and represent almost the totality of cruising industry in European Arctic. AECO has now 36 members, 20 of which operate approximately 25 expedition cruise ships with capacities, currently, of 8 to 318 passengers. AECO'S has a developed culture of corporate responsibility and its objectives include ensuring that cruise tourism in the Arctic is carried out with the utmost consideration for local cultures, cultural remains, the natural environment and safety hazards at sea and on land. The association advocates the interests of the expedition cruise industry. It is actively involved in all efforts to regulate or create best practice rules about the Arctic tourism. It has already established a mandatory guideline for its members, a member ship tracking system and cruise database, as well as a system for those data public proliferation and numerous training, conferences and environmental sensitivity volunteer actions.

Generally the cruise ship industry is operating large and medium sized ships, some of them ice capable, along Greenland's coasts, North Cape and around Svalbard. The cruise ships now under construction will further expand both passenger capacity as well as the number of ships serving the Arctic market.

Many Arctic cruise ships are starting to visit destinations that were once totally inaccessible to the public, such as the North Pole, Northwest Passage and the Northern Sea Route. Between 1984 and 2004, 23 commercial cruise ships accomplished transits of the Northwest Passage; seven commercial tours were planned for 2008 alone. In summer 2010, two cruise ships sailed the length of the Northwest Passage (NWP), as did one each in 2011 and 2012. During summer 2012, The World, a 196.3 meter condominium ship, became the largest tourist ship to transit the NWP. The NWP has also experienced a notable increase in adventurers and small yacht voyages in 2010 (Arctic SAR 2011), 2011 (IMO 2010), and 2012 (IMO status 2012). These small ship voyages along the NWP present a new set of challenges for the maritime authorities in the remote Canadian Arctic. To put these numbers in perspective, as of the 2012 navigation season, there have been only 183 full voyages of the NWP since Roald Amundsen's voyages aboard Gjøa from 1903-1906 (Headland 2012). However, development of a trans-Arctic route through the NWP does not appear likely in the near future.

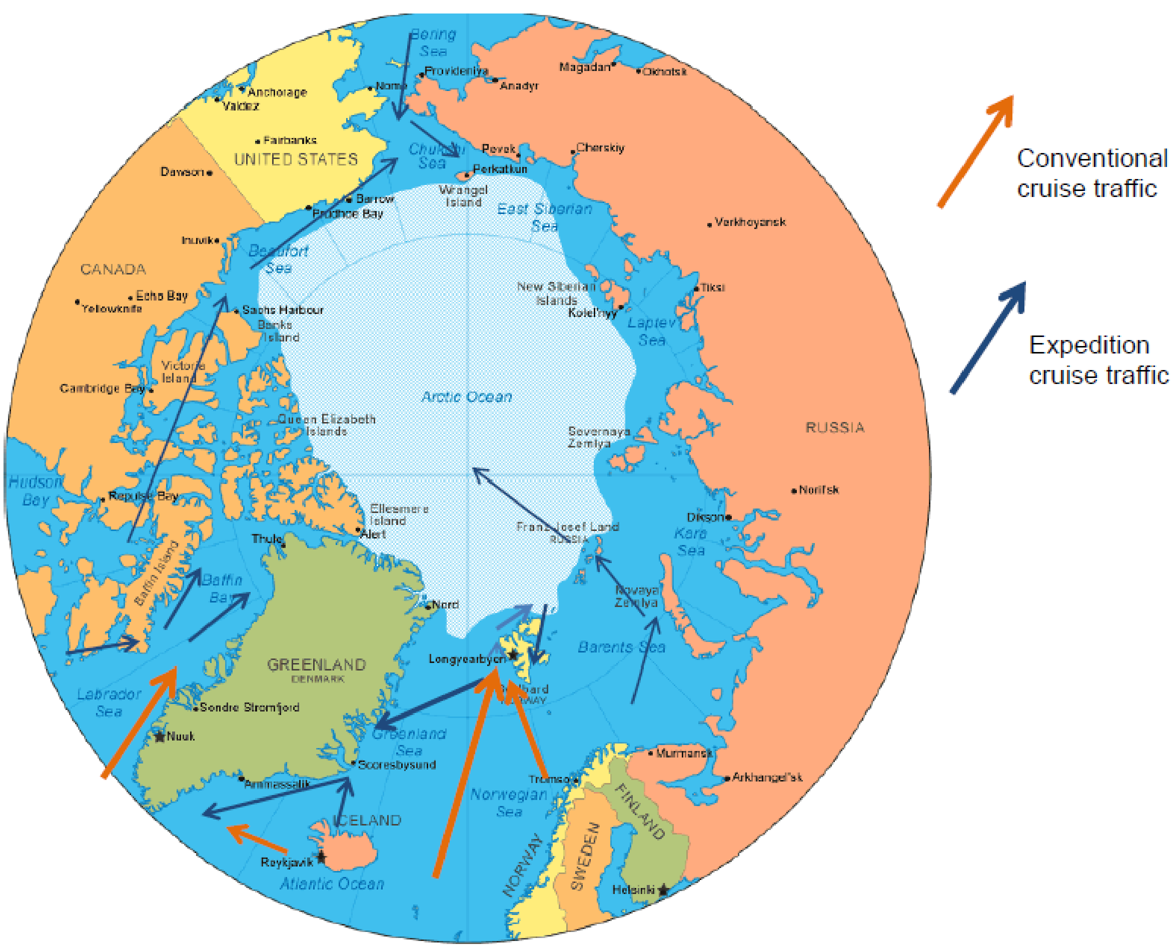

Figure 18: Cruise traffic directions (source: AOR, 2013)

2.2. Industry overview

Looking in the big picture, passenger ships are a significant proportion of the shipping activity reported in the Arctic. Arctic passenger moving purposes include: ferry services, small and large cruise ships and all other ships where passengers are transported, whether for tourism purposes or otherwise.

The type of activity taking place varies by region. In Norway, Greenland and Iceland, some of the passenger ship traffic consists of ferries. This is also the area were the bulk of passenger ship traffic is located. In Alaska and the Canadian Arctic, ferries are not routed and all passenger traffic would be ships for marine tourism only. Some services, such as the Hurtigruten around Norway and ferry service to Iceland and Greenland from mainland Europe are hybrids, serving both as ferries and cruise ships.

Nearly all passenger ship activity in the Arctic takes place in ice-free waters, in the summer season. The only passenger ships that have travelled in ice-covered waters were the Russian nuclear icebreakers that took tourists to the North Pole, voyages they have been making for tourism purposes since 1990.

In the Arctic, marine tourism is highly diversified and is driven by five main types of tourists. These include:

- Mass market tourists primarily attracted to sightseeing within the pleasurable surroundings of comfortable transport and accommodations
- The sport fishing and hunting market driven by tourists who pursue unique fish and game species within wilderness settings
- The nature market driven by tourists who seek to observe wildlife species in their natural habitats, and/or experience the beauty and solitude of natural areas
- The adventure tourism market driven by tourists who seek personal achievement and exhilaration from meeting challenges and potential perils of outdoor sport activities
- The culture and heritage oriented tourism market is driven by tourists who either want to experience personal interaction with the lives and traditions of indigenous communities, or personally experience historic places and artefacts.
- A distinct possibility is that as the climate is changing there will be new type of tourists venturing to the area the “doom” or “last chance” tourist. These individuals will venture there in order to witness for maybe last time scenery and wild life under threat.

While Arctic ship-based tours are booked well in advance, quite large part of their itineraries are dependent to a variety of parameters. The final/actual route and the ports and communities visited depend on the ice conditions, the difficulty of access and risk of access. Cruise ships intentionally travel close to the ice edge or the shorelines for wildlife observing opportunities, thus increasing the risk of collision with ice, the risk grounding and other hazards.

As the Arctic cruise industry continues to grow with it will grow the size of the ships that will be sent to the arctic waters. Despite the boom in construction of new cruise liners the last 15 years, the vast majority of them are not ice capable and even more not designed or constructed to operate in Polar environment.

The cruise ship industry considers Arctic voyages to be a vital and especially lucrative part of their international tourism product. This is apparent when considering the price that tourists pay to travel to this region. In 2008 the prices range from $US2.900 to $US55.000 per person. The cruise ship industry intents not only to maintain an Arctic presence, but to expand in terms of ship passenger capacity, destinations and extended seasons of operations. That is evident on the next year's trip through the North Western passage, which triggered this study. It is also expected to be encouraged by circumpolar nations that view tourism as an important revenue and a tool for growing and strengthening their economies.

In 2004 more than 1.2 million passengers travelled by 2007 that number had more than doubled. Despite the global economic difficulties the industry didn't lose all of its momentum and statistics describe a slower but steady expansion.

According to Cruise Lines International Association (CLIA) after the economic crisis the bed days available for cruises in and around the Arctic (north Europe Canada and Alaska) are in steady increase and are nearly doubled. Itineraries options are also growing but slower. This indicates that the trips to these areas become longer and the ships bigger and possibly executed with fewer ships. At the same time more innovative and adventurous activities are available like glacier trekking and overnight survival on a remote Island were fishing and fire building is thought.

The areas visited by the cruise ships in Greenland are also reported changed. Driven by increased demand in adventure tourism, the local tourism bureau has reported that by 2009 there has been a marked increased interest in trips to the far North of Greenland, an area that has traditionally not been visited by many tourists. In 2008, 28 ships were scheduled to travel as far north as Uummannaq or Qaanaaq, both destinations far inside the Arctic Circle and far away from good infrastructure or emergency response capabilities. Many of the cruise ships traveling to these destinations are also likely not ice-strengthened.

Though, that area's seas are classified as ice-free in the summer that does not mean that ice is not present and, even in small pieces, ice can pose a serious hazard. The Greenland government is very conscious of the rapid growth in cruise ship traffic in their waters and Island Command Greenland, the naval service covering Greenland waters that is responsible for both rescue and emergency operations, has recently put an increased focus on cruise activities in Greenland waters.

Marine Incidents	Total events	Events since 2000	Percent since 2000
Polar cruise ships sunk 1979-2013	11	8	72
Polar cruise ships running aground 1972-2013	32	21	66
Pollution and environmental violations 1992-2012	90	68	76
Disabling by collisions, fires and propulsion loss 1979-2013	47	41	87

Figure 19: Marine incidents involving cruise ships in Arctic and Antarctic waters (aggregated from reports from national coast guards, admiralty courts, insurers, and www.cruisejunkie.com accessed at 21/03/2015)

3. Known issues and Evaluation of current regulatory framework

This chapter is to be a summary of all the issues mentioned or implied in the previous chapters in order to start focusing our attention to the residual regulation matters concerning Arctic cruising ships.

3.1. Ship Safety issues

One thing is common across this section: The role of POLAR WATER OPERATIONAL MANUAL, as described by chapter 2 of the RESOLUTION MSC.385 (94) INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS (POLAR CODE). Among other things it is used as a proactive measure in order to mitigate risks for class C ships operating in polar waters, while they abide by more lax standards. The general problem is that "The safety net is only as good as the POM and the POM is only as good as how it is enforced by the flag state. There are many who have both eyes closed," said Sven Gerhard, head of hull and marine liabilities for Allianz to the newspaper "The guardian" in Friday 21 November 2014 article titled "Polar code agreed to prevent Arctic environmental disasters". Additionally regulation 1.3.3:

"For category C cargo ships, if the result of the assessment in paragraph 1.5 is that no additional equipment or structural modification is required to comply with the Polar Code, the Polar Ship Certificate may be issued based upon documented verification that the ship complies with all relevant requirements of the Polar Code. In this case, for continued validity of the certificate, an on board survey should be undertaken at the next scheduled survey."

is relaxing the inspection for compliance web for class C ships.

3.1.1. Ship ice going capability

Multiple standards for the ships "ice class" designation are in use, utilizing different approaches to it and just as many systems. The Polar Code is harmonizing the multitude of state law requirements by introducing the new internationally mandatory standard: the IACS Polar Class, adopted since 2008 by Arctic States as part of the MSC's 76th session "Guidelines for Ships Operating in Arctic Ice-covered Waters". IACS Polar Class is method of classification of ships capability to operate in ice covered polar waters, and it is a product of a very long deliberation between all ice class systems, combining their experience and scientific backgrounds in a single 7 category system.

Never the less the current draft is not perfect, at least form the scope that not all stakeholders are fully satisfied by its requirements and thus the existence of vocal criticism. Reservation is expressed from a variety of experts that the PC is allowing non ice strengthen and old, out dated ships to classify as Polar class 6-7 ones, through great leniency to their classification inspection, and thus theoretically allow them to operate in considerable risk for themselves, their crew and the environment in polar waters. Indeed the most restrictive demands are provided for class A and B ships constructed after 2017 and class C:

“A category C ship need not be ice strengthened if, in the opinion of the Administration, the ship's structure is adequate for its intended operation” (Regulation 3.3.2.4 RESOLUTION MSC.385 (94))

Furthermore, it does not provide for minimal engine power and thus rejecting the valuable system approach of Finnish Swedish Ice classification.

In support of the PC’s decisions: experience accumulated by the prominent polar countries of Canada and Russia include no regulation in engine power of the ship and its left to the owner to decide about it more efficiently based on its ships intended usage, and to the administration to certify it in temporal base. The same goes for the ships Polar Class designation for which the class 6-7 ships are expected not to operate in ice covered seas and generally only for limited time in Arctic waters, (summer ice free season). PWOM in coordination with provisions of CHAPTER 9 – SAFETY OF NAVIGATION and CHAPTER 11 – VOYAGE PLANNING, is again stepping in to allow class C ships to mitigate such risks by avoiding challenging conditions. In theory this might be prudent and enough, but usually reality differs, as proven in the past, by introducing unreliability factors to PWOM quality.

3.1.2. Ship stability with icing

The PC is also has an effect in this subject. It provides comprehensive requirements but again it is limited for class A and B ships, class C is left to “the Administration”. (Regulations 4.2.2. and 4.3.2.1. of RESOLUTION MSC.385 (94) INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS (POLAR CODE)). That is an issue especially if someone examine it form the point of view that new class A and B ships are the least susceptible to ice damage, since their structure also abide by tougher regulations. Class C that might not even be ice-strengthen, operating in waters infested with icebergs and ice concentration less than 1/10. Again, PWOM in coordination with provisions of CHAPTER 9 – SAFETY OF NAVIGATION and CHAPTER 11 – VOYAGE PLANNING, is again stepping in to allow class C ships to mitigate such risks by avoiding challenging conditions. In theory this might be prudent and enough, but usually reality differs, as proven in the past, by introducing unreliability factors to PWOM quality.

3.1.3. Navigation and operation in Arctic

As mentioned before navigation in arctic is problematic because of the present of ice and because it is largely uncharted. The Polar Code makes several demands concerning the ships operational safety. Chapter 2 demand risk based procedures: *"in order to avoid encountering conditions that exceed the ship's capabilities. ",* and procedures to be followed when such conditions are encountered. Furthermore Chapter 9 is dedicated to navigational safety, making request for navigation information exchange capabilities, additional navigational equipment and equipment functionality. Chapter11 deals with voyage planning and Chapter 12 with crew training requirements.

Despite the difficult conditions of the region, the relevant infrastructure limitations and the critical risks that these two factors are correspond with; no criticism about the provisions made about this topic. That does not mean that those risks do not exist that they are mitigated into acceptable levels, but that all available precautions were taken.

3.2. Environmental protection issues

The presence of a ship, in any kind of waters is bringing the same problems emissions of noise, engine, garbage and sewage, ballast water and animal-ship collisions. If we consider cruise ships then we also have to take into account their passengers activities. The Arctic has the same issues to deal with but the environment is much more sensitive. Polar code again is one of the landmark regulations for the region but it is widely criticized about its environmental shortcomings. At the same time no uniform and mandatory rules are in force about visitor activities.

3.2.1. Bird colony protection

Polar code instructs that all transits in polar waters should be charted in a way that they will avoid protected environmental zones and avoid migratory routes for marine mammals, but ignores the impact on bird habitats. As mentioned in chapter 1.3. bird living in the region are important, sizable and particularly sensitive to external disturbances throughout the year. Partially they are covered under PC regulations 11.3.6-8. Since they coincide with mammal zones (70 of 85 in total) and internationally protected they remain about 15 areas that birds use but not the mammals. Additionally still the traffic of big cruising ships remains low but the increase of small yacht can be worrisome.

3.2.2. Ballast water

Ballast water is an important issue for the Arctic since it is the main way to introduce marine invasive species into the region, and traditionally cruise ships use a lot of it by nature of their design. The PC is not addressing the issue thought for one main reason, that it was designed in order to avoid overlapping regulations with other resolutions and law texts, in this case with Antarctic treaty and BWM Convention. Also till fairly recently the norm was that tourist ships were not frequent into the region. The latest BWM convention by IMO was a great step forward and could have resolved the problem to a reasonably low risk levels but as of January 2015 it is not yet become effective lacking the vote of another 2-3% of the global fleet, despite that all Arctic nations have already ratified it. Till then ships have to comply with costal state law, high seas are unregulated and common standard for the entire region are unheard of. At the same time Antarctic Treaty has a total ban on ballast water discharge in that region.

3.2.3. Garbage and sewage

That is another point of intense criticism for all Arctic shipping regulations and environmental protection. All ecological focused NGOs, several general focus one like the Smithsonian and polar experts are complaining for the severely loose regulation on the matter despite they are important ship based pollution factors.

Most of the modern cruise ship designs have improved full treatment plants for at least their liquid and organic waste products. This treatment process, involve emptying the by-products either directly to the international waters or port facilities that can handle them. The few port facilities around the Arctic can't handle the disposal of large cruise ship waist products at this time and introducing volumes of "southern origin waste" in the region is dangerous, because it can introduce foreign organism to the local ecosystem with incalculable ramifications to it. Moreover, cruising ships produce far larger garbage and sewage water volumes, not only than any other ship but also than many local community hubs, and on top of that the Polar Code Hazard Identification Workshop Report (DNV, 2011) report that according to:

- (AMSA, 2009, page 137),
- Claudia Copeland, Congressional Research Service, Cruise Ship Pollution: Background, Laws and Regulations, and Key Issues 4 (last updated July 1, 2008). 15 EPA 2008 Cruise Ship Assessment, at 3-6.
- CRS Cruise Ship, at US Navy Naval Sea Systems Command and US EPA Office of Water. Technical Development Document: Phase I, Uniform National Discharge Standards for ships of the Armed Forces 5.0 (1999).

“*Discharges of grey water, the wastewater from galleys, showers, laundries, as well as food pulp, represent an environmental concern for polar waters. The U.S. Commission on Ocean Policy reported in 2004 that an average cruise ship produces 3.8 million liters of grey water each week. Substances found in grey water include fecal coliform bacteria, oil and grease, detergents, nutrients, metals, food waste, and medical waste14. Analyses by U.S. EPA and the Alaska Department of Environmental Conservation indicated fecal coliform levels of 36,000,000 CFU/100mL and 2,950,000 MPN/100mL, respectively, for untreated cruise ship grey water, which is higher than, by orders of magnitude, bacteria levels identified in untreated domestic wastewater. Grey water also has potential to cause harmful environmental effects due to concentrations of nutrients and other oxygen-demanding materials*”

Despite the above facts, Arctic is treated like a regular High Sea zone around the globe. More lenient than other designated special areas like Mediterranean Sea and of course the model of Antarctica, allowing discharges or sewage and garbage 12 NM from ice sheet edge or in some cases even closer.

It is important to notice that no large permanent human population hubs like town, villages, mines and oil production platforms are located in Antarctica, a fact that can influence relative regulation both ways. It can help into loosening them, because the permanent human populations already produce such pollutants in a steady base, and because infrastructure that will allow zero discharges to the sea for both ships and local population will be exorbitantly expensive. Intensify regulation because the additional volume may exceed the environment’s capacity to recycle and neutralize them, and that the foreign to the region substances that the cruise ship passengers use in order to produce them might increase the number of such invasive species and pollutants in general increasing accordingly the related environmental risks.

3.2.4. Air pollutants

In that category fall the CO2, SOx, NOx, Black Carbon and other air pollutants included to ships engines and incinerators emissions. Big cruise ships are using large amounts of power for maintaining their facilities and so they operate their generators almost 24 hours 7 days a week. Their usage of fuel is copious and their emissions significant, despite the efforts made in the recent years to reduce their emissions or clean them up. Their quality is directly linked to their engine technology and type and quality of their fuel; the most pollutant of which is Heavy Fuel Oil (examined in the next paragraph).

Those pollutants emissions in the region receiving no particular attention at all outside the general regulations found in MARPOL Convention Annex VI: Regulations for Prevention of Air Pollution that does not specify “emission control areas” in the region. That is despite the role they play in costal water acidification and the fact that the Arctic waters are not easily exchange or circulated with other Oceans. That lack of vocal criticism might be explained form the facts that ship traffic in the region is still low comparing to other Oceans and that there no exact information exist on the impact CO_2, SO_x, NO_x, have to Arctic waters in general and that we also lack understanding of the exact impact magnitude and mechanism of black carbon effects on arctic environment (resent Norwegian study report that thy were both overestimated by about 50%). It can be argued thought that if we aiming for region conservation and since emissions control zones are already established by Arctic countries it could be useful, easy and proactively prudent to make one for the Arctic region.

3.2.5. Heavy Fuel Oil

HFO is the most noxious and heavy type of fuel, extremely damaging for marine environment’s (flora and fauna) and difficult to recover from the sea in the event of a spill. The usage and transportation of HFO in the region, despite the recognized particular environmental sensitivity and importance (local and global) of the regions ecosystems was not limited.

It seems that indeed the need of crude oil transportation from local oil fields, its usage by the tankers and other cargo ships for cost reasons, and the capability for at least limited response to industrial accident by the Arctic states as described to their 2012 legally-binding “Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic” gives sufficient pretext to allow the transportation and usage of HFO, despite its ban from Norwegian waters. Furthermore the ship traffic volume is small considering other the Oceans and although the conditions are quite hostile and add risk into causing accidents the new PC is mandating specific regulations for the fuel tank locations on board in order to mitigate the risk of spills during accidents.

On the other hand the model conservation laws of Antarctica and Norway are showing the way and insist that a ban is possible and useful preventive measure. The limitation of using and carry HFO in the region can also be both, cause (for) or effect of the implementation of an air emissions control zone in the region.

3.2.6. Noise emissions

The noise emitted by the ships functions such as propulsion, machinery, depth finding devices and by just its hull propagation in the Arctic environment. The ship noise propagation trough in

Arctic environment is a very well researched field basically because of its military applications. Those ship noises impact to the environment on the other had are not sufficiently known to marine biologists. It is established that depending on their frequency and intensity, can disrupt communication between animals (e.g. whales) or even force animals abandon important habitats if frequently visited during sensitive time periods (mating and reproduction), but the exact mechanism that link a sound disturbance to the that results are not sufficiently documented. As the following graph from (NRC, 2005) about marine mammal populations and noise presents the chain or mechanism that link cause and effects is barely understood despite some very well studied fields. The full understanding of its intricacies can lead to improve the relevant measures, for example traffic exclusion zones around areas of increased environmental importance. Till then no rule in any law text provide any kind of regulation on the matter for the Arctic region.

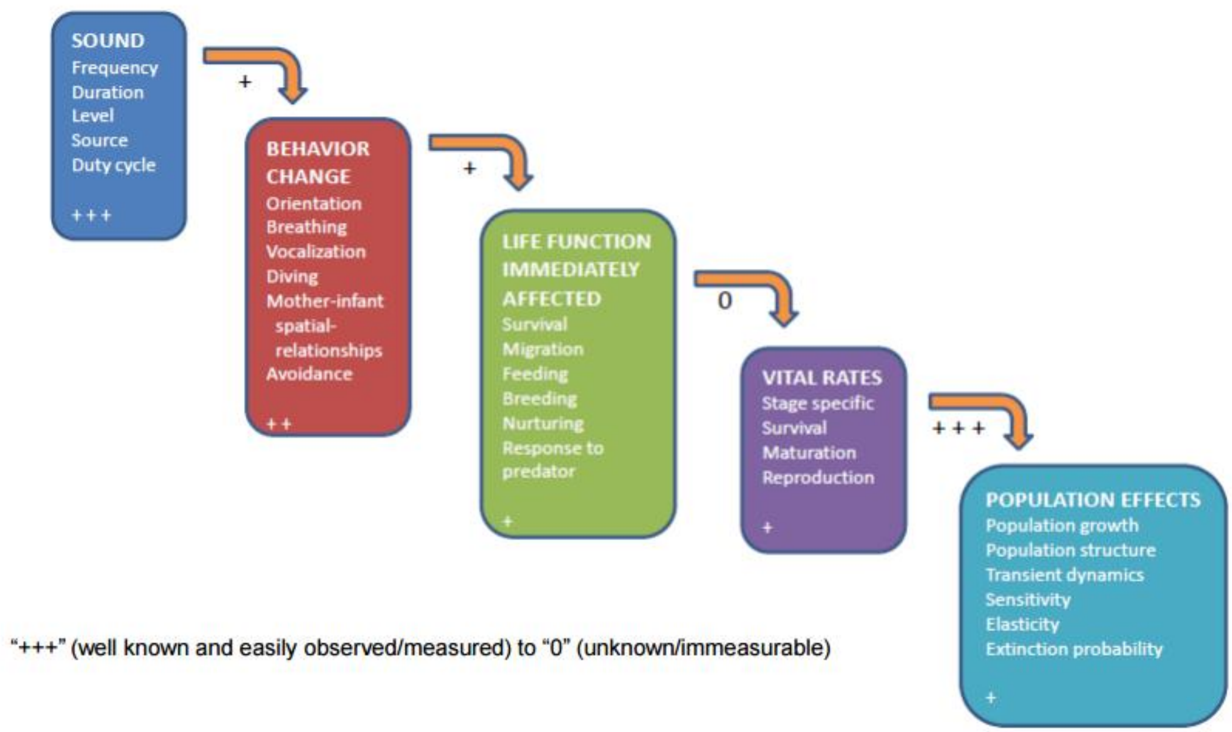

Figure 20: Linking sound to marine animal population effects (Source: NRC 2005. Marine Mammal Populations and Noise)

3.2.7. Tourist shore landing access

It is to be expected that at least a limited number of passengers of the cruising ships will want to have access to the shore during the programed stops of the cruising ship that can take the form of organized adventure excursions or mass "shore leave" events. Such access can have adverse effects on local environment in the form of local flora trampling, introduction of foreign species, disturbance of animal colonies and unrestricted garbage disposal, areas that are not already populated are more sensitive in such disturbances.

Antarctic treaty can be considered as model for regulate such activities, limiting the number of persons making a landing on the continent annually, controlling the location of such landings and introducing contamination control protocols. Arctic is not benefited by such blanket legal protection web. The control of such activities is left to local law about protected ecological areas, voluntary best practice guidelines introduced by interested parties (for example AOR guidelines) and local authorities.

3.3. Passenger safety

Ship safety is the best way to ensure passenger safety, but in event of ship evacuation specific provisions have to be already made in order to survive a hostile environment, especially if the persons that have to endure it are untrained for survival and the remoteness of the area that are stranded corresponds long waiting time for SAR units arrival.

The Polar Code is harmonizing the costal state regulations with mandatory requirements. Chapter 2 of the code demand that the PWOM contain risk based designed procedures for incidents in the region. Furthermore Chapter 8 covers lifesaving appliances and arrangements, while Regulation 10.2.2. "Survival craft and rescue boat communications capabilities" ensures that will be able to call for help.

Despite the difficult conditions of the region, the relevant infrastructure limitations and the critical risks that these two factors are correspond with; no criticism has been made about the provisions made about this topic. That does not necessarily mean that those risks do not exist or that they are mitigated into acceptable levels, but that all available precautions were taken.

3.4. Infrastructure

As the region was not frequently navigated the marine related infrastructure of the region is still lacking on critical sectors. As mentioned in the previous chapter a significant lack of proper nautical maps for all marine areas of the region is to be considered, while SAR capabilities are limited and port services rare. Such infrastructure issues are touching or even cause problems addressed in other sections of this chapter but is still valuable to mentioned separately.

UNCLOS Convention assigns responsibility to states about navigation safety and SAR operations it is also the state that estimate and decide the needs and the appropriate and available resources that can provide to honour such responsibilities. Given the expense, the variable usefulness and the sovereignty issues attached, states cannot be forced to provide adequate level of such infrastructure and especially do that beyond their means.

In the case of port facilities and their services, their existence is subject to local economic or community needs, or state sovereignty issue and thus their existence or not can't be subject to international regulation.

3.5. Cultural

Tourism is an important tool for providing the necessary income for communities' survival in many regions of the planet, but it does not come without problems for those communities, coming from a country with a developed tourism industry and decades of experience with it I can assure that.

Greek island population are quite often several times larger than the visitors hosted at any given time of tourist period and still privately complain about summer overcrowding of their land, obstruction of their other seasonal activities equally important for their prosperity, foreigners misconduct during their stay, the strain of local resources that their hosting demands (mainly water, electricity and garbage management) and last but not least their numbers impact on the environment and landscape . In the Arctic the communities are by far smaller and as ships are getting bigger their passengers will outnumber several of their communities by their presence. On top of that we have to consider that their culture can be considered more private, and the cultural difference with their visitors wider. All texts included in this report's bibliography that have sections about cultural/community issues recognize the same problems, and that the communities need external help to realize and solve those problems as part of a sustainable tourism development strategy.

Such issues are of difficult nature to consider in Arctic region terms since they have to do with constantly changing subjective, local factors such as resident's feelings. Furthermore no prohibitive legal tools exist that can be used by the local authorities in order to address such problems like for example the Antarctic treaty, that can be considered a model for regulate such activities, limiting the number of persons making a landing on the continent annually, controlling the location of such landings, for ecological reasons though.

Thus, so far, the control of such problems is left to local law, voluntary best practice guidelines introduced by interested parties (for example AOR guidelines) and local authorities (if any) agreements with cruise and/or tourist operators.

Another issue that is stems from cultural based reasons is the almost total so far exclusion of native population from any process concerning regulation of their region and their activities.

Usually because they do not have enough resources or many -if they have at all- members adequately educated to even follow such developments, much more to offer detailed, meaningful proposals required by the official procedures, their point of view is ignored, omitted or not even asked for.

3.6. Governance and Law

3.6.1. Law Harmonization

Although during the last years massive efforts by the IMO and Arctic Council are driving home two mutually completing texts, the Polar Code and Arctic tourism best practices, and thus achieving significant improvements in the scope of regional marine and tourist law harmonization the goal set by many of a homogenous law web frame, oriented towards sustainable preservation of the region has not been achieved yet. Gaps are still left in the system to be found, as well as inadequacies. For once structural demands by the Polar Code are referring to IACS unified rules, which according to Sections I2.14., and I2.15.2., the stem and stern frame design according requirements of member societies for load definitions and response criteria determined by these member societies. That simple reference allow leeway in different certification standards and prove that harmonization of even core rules is not, yet, fully achieved. Moreover, failure to provide adequate minimum environmental protection standards will drive at least some Arctic countries to keep enforcing different set of regulations inside their legal reach.

The realization of such lofty goal will require the harmonization of state regional interests at least as deep as marine, navigational and environmental, safety.

3.6.2. Persisting legal jurisdiction issues

Because of the leeway that the Conventions regulations need to have in order to be applicable in most cases and acceptable by constituent states, someone cannot ignore the need for further disambiguation of articles such as the infamous 234 of UNCLOS and SOLAS Section G-3.2 paragraph 2 about the definition of “ice-covered waters”. Furthermore as the Ice sheet continues to retreat and fluctuate annually the matter is almost impossible to solve especially if a reliable, constant, accurate and commonly acceptable system for monitoring and reporting ice conditions in the region is not in place.

Moreover we have the issue of port and state flag control jurisdiction that create a legal loophole for ships transiting the region to avoid inspection for compliance to the regional rules if they don’t go into regional ports. That is important when the quality of the POWM comes in question in conjunction with opportunity flag usage, since the manual is to be written under flag state law and inspected by flag state authorities in the first place.

3.6.3. Compulsory versus voluntary nature of regulations

The introduction of a mandatory Polar Code has proven that mandatory provisions can be introduced for the region, despite the long process required by the complexity of the matter, as long as the stakeholders -states, classification societies, ship-owners and seafarers- recognize their common interests, and that the mandatory framework can be further expanded if the need is realized.

At the same time though, it is not possible to regulate all residual regional matters in that way. For example Arctic tourism issues can not enjoy a regional mandatory code, since local needs (especially the resident human communities) can be whimsical or at least difficult to predict and tourism matters fall under the control of sovereign state legislation. Arctic states under the Arctic Council that has the necessary structure in place to give voice to indigenous population, have to agree in common standards that legal texts concerning the region has to agree with and then move forward to find the checks and balances between compulsory rules and voluntary guidelines.

3.6.4. Antarctic treaty model as achievable Arctic solution

The above mentioned legal hurdles, processes and the legal precedent of the Antarctic treaty are still fuelling the idea of an Arctic treaty. The sentiment seem to remaining strong to a variety of Arctic experts and not without a merit, undeniably it would be a development that would eliminate many of the current difficulties and further the goals of most of the case by case legal treaties, but remain extremely problematic by the simple fact of countries with coastal waters and citizen populations exist in the region -including “great powers”- and their often conflicting geo-economical and geo-strategically interest that this reality brings to any such project.

4. Evaluation of current regulatory framework

The chapter presents the method of analysis for the previously defined problems. Then it provides the results of the usage of the tool for each of the issues intrudes in the previous chapter and briefly describe the thinking possess of the time consuming deliberations and reasoning followed.

4.1. Method

In order to evaluate whether a change in the regulations is needed as a result of a gap, insufficiency or if an effective change is possible, the usage method of SWOT analysis was necessary. It has the flexibility to factor in all the different aspects of a regulation decision and is well founded in practice and literature for making strategic decision.

SWOT analysis was created by Stanford University's and is credited to two Harvard Business School Policy Unit professors – George Albert Smith Jr and C Roland Christiensen during the early 1950s. In 1950s Kenneth Andrews, an HBS Policy Unit professor, further developed its usage and application. All the contributors were organizational strategy specialist. HBS during 1960s further developed the tool to the modern time form.

By specifying clear objectives and identifying internal and external factors that are either helpful or not, a short and simple SWOT analysis is a useful resource which may be incorporated into an organizations strategic planning model.

The tool aims to identify the key internal and external factors that are either helpful or not, in order to achieving an objective and groups this information into four categories:

1 Strengths: Internal attributes that are helpful to the organization to achieving its objective
2 Weaknesses: Internal attributes that are harmful to the organization to achieving its objective
3 Opportunities: External factors that help the organization achieve its objective
4 Threats: External factors that are harmful to the organization to achieving its objective

Steps necessary to execute strategy-oriented analysis involve: identification of internal and external factors, selection and evaluation of the most important factors and identification of relations existing between internal and external features.

4.2. Ice capability and icing stability rules

STRENGTHS	WEAKNESSES
• Safer ships • Regulatory clarity • PWOM quality irrelevant • Hydrographical, meteorological and navigational problems mitigated.	• Over regulation? • Expensive • Risk base approach marginalized
OPORTUNITIES	**THREATS**
• No navigation error possibility • New ship constructions • Less inspections required • Upgrade of old ships • Work load of bridge improves • Higher quality of ships • SAR stress mitigated • Corruption control • Murphy's Law	• Less available ships • Not compliant ships usage • New constructions or upgrades impact • PWOM role marginalized • Market flexibility

Advantages of a stricter regulation that would demand ice strengthen ships with the corresponding intact and damaged stability calculations can be that there will be more margin for navigation errors caused from Hydrographical, meteorological and navigational knowledge gaps. Crew's workload, quality of training and experience level factors importance is becoming less critical in difficult situations, and the quality of their state flag approved PWOM is mitigated. Murphy's Law would find fewer factors to apply on. Also the regulatory harmonization would be improved since the local authorities won't need to issue demands for those ships approval and so there will be less rules, faster bureaucratic procedures, less stress to improve SAR capabilities, less inspections and less opportunities for corruption. At the same time that will be an incentive for new construction of ships and the upgrade of some existing ones, work that some of the arctic countries shipyard might need.

That current framework on the other hand, provides a certain degree of flexibility in the industry of polar cruising by bringing ships build for other conditions in the region if profit is to be made, or the ship is forced out from other markets. At this point the majority of big cruising ships operating in the region are not ice strengthened. The financial gains for ship-owners/operators and the locals are clear in that way. The tightening of regulation will have an impact to the general plan of making regulations about shipping by the risk assessment method in order to improve the financial viability of the sector, a philosophy that is currently promoted and established. It can be argued that it is a return to the old over construction and over regulation, damaging mind frame that stifles improvements and innovation. Constructing new ships or upgrading existing ones can be a very expensive entry fee for a lucrative but small market which creates important revenue streams for the local communities.

New category A and B regulation will eventually phase out any such category ships in the future; those ships are already significantly ice capable so the conversation is mainly about category C ships. IACS rules classify them for thin ice operations; clearly this is dangerous for ships that do not belong to a Finnish regulation ice class.

It would be clearer to make a category D and/or class PC8 that will include all marginally or not at all ice strengthen ships suitable for open water or nearly open water conditions only, for which all the relaxed rules would apply. The parallel elimination of exceptions for class C ships, based to the open water operation or case by case approval assumptions, could be tighten for future designs like category A and B. That assures that the regulation will be further harmonise and there will be no need for case by case approval for all those diverse ships that currently fall in class C.

4.3. Navigation and operations in Arctic

STRENGTHS	WEAKNESSES
• Safer ships operations • Regulatory clarity • Assured quality • Advance of Risk base philosophy	• Expensive • Time consuming process
OPORTUNITIES	**THREATS**
• Proliferation of ice navigation experience • Less inspections required • Trust building • Elimination of risky operators • Confidence to the crew • Improve training standards	• Over regulation • Stifling of new approaches • Could be diluted by political manoeuvring during its creation

Standardisation of quality can hardly be a bad thing especially when we deal with safety. The PWOM document as other documents that detail procedures and required to be on ships by maritime law, it is to be written and inspected under the flag state law/authorities. That raised questions steaming from bureaucratic weaknesses or intended loopholes mainly in flag of opportunity registers. PWOM is very important in the current regulation framework for polar navigation as it is loaded with all risk mitigation measures needed to safely traverse high latitude seas. The process to formulate standards for that document will be time consuming and probably expensive (in IMO scale) like it was the creation of a mandatory Polar Code and the threat of being over restrictive would be ever present during its creation but the potential gains are equally valuable, if done right. It would proliferate ice navigation experience gained by the Arctic countries and will further advocate for the risk base philosophy's advantages. It will simplify the job of the inspecting authorities and will build common trust ground between the flag state authorities. It can also improve the crew's confidence and peace of mind and will probably improve their training curriculums on the long term.

Under that scope it would be advisable to be introduced quality standards for the PWOM document in the model of crew training requirements of the Polar Code

4.4. Bird colony protection

STRENGTHS	WEAKNESSES
• Easy addition on current regulation text • No significant change in currently allowed routes	• Added avoidance zones
OPORTUNITIES	**THREATS**
• Enhance of ecosystem approach on environmental protection • Prove ecological sensitivities	• Loss of tourist attractions

The difference is a small number of areas since most of the bird colonies are located in the same zones that marine mammals move and thus they are already are protected. The text is already in place in Polar code and the addition of just one word is needed. It will create a few added avoidance zones but the changes will not be significant and might be exploited to prohibit access by tourists but that is a minimal risk since that will limit access in other regions too.

It's an easy change with no significant impacts and implication with the current rules and can be a showcase of environmental sensitivity and promotion of IMO policy of ecosystem approach on such matters.

4.5. Ballast water disposal

STRENGTHS	WEAKNESSES
• Eliminate a factor for species invasion	• Overlapping with already existing regulatory text. • Enforcement of control might be impossible
OPORTUNITIES	**THREATS**
• Enhance of ecosystem approach on environmental protection • Prove ecological sensitivities • Strong incentive for port infrastructure improvements	• Regulatory confusion • Increased operation costs for all shipping • Increased policing cost

It's a straight-forward case. A total banning of ballast water dumping has political gains to be made and eliminate a species invasion vector but is overlapping with risk based regulation almost in place by a pre-existing treaty. Furthermore a total ban might be not be able to enforce or at least not with a reasonable cost.

Since the BWM convention is close to become enforced and mandatory no case can be reasoned for additional regulatory effort without new causes.

4.6. Garbage and sewage dumping

STRENGTHS	WEAKNESSES
• Adequate protection of sensitive zone • Improve of protection level • Classification as a special zone • Critique mitigation • Regional state flag law harmonisation improvement	• Fairly extensive changes in existing regulatory text. • Expensive enforcement • Cost for improving ship amenities
OPORTUNITIES	**THREATS**
• Enhance of ecosystem approach on environmental protection • Advance of Risk base philosophy • Prove ecological sensitivities • Strong incentive for port infrastructure improvements • Risk base approach prove of improvement and promotion • Work for shipyards (upgrades) • Further regulation might become irrelevant	• Regulatory confusion • Increased operation costs for all shipping • Increased policing cost • Over regulation?

The current protection level offered is the most unanimously criticised measure of the Polar Code convention. Recent studies warn that threat might be underestimated. Improvement will prove that the system work, it will further harmonize the local law framework and will mitigate criticism. It can be a golden ticket for the establishing and proving of both risk base philosophy and ecosystem approach. Moreover it will create incentive to improve both ships and local ports creating work revenue regionally and globally. Furthermore it would render any further regulatory need irrelevant (Arctic treaty). Problems is that the text changes might need to be extensive, especially if it is chosen to go a step further into classify the Arctic region as a special interest zone. Enforcement might be proven to be problematic and will curry certain cost to shipping operators in general. Cruising industry will probably not have additional cost since ecological awareness of their clients already modified their operational methods and their ship capabilities.

AOR operators are already have mandatory guidelines for their members but since the risk is great it will not be bad to made a mandatory provision, especially if it apply only for cruise ships. On the other hand that such a regulation will also apply for the rest shipping their risk is far smaller and will create added cost that are not back breaking but also not needed.

4.7. Air pollution and HFO

STRENGTHS

- Protection of a sensitive zone
- Critique mitigation
- Regional state flag law harmonisation improvement
- Fairly limited changes in existing regulatory text. (HFO banning only)

WEAKNESSES

- Expensive enforcement
- Cost for ship upgrades
- Works against Risk base philosophy
- Accidental spilling is already mitigated by regulation on fuel tank position on ships.

OPORTUNITIES

- Enhance of ecosystem approach on environmental protection
- Prove ecological sensitivities
- Mitigation of spill control costs (readiness and event frequency)
- Work for shipyards (upgrades)
- Mitigation of need of future regulation

THREATS

- Increased operation costs for all shipping
- Over regulation?

Norway has already ban HFO from her waters and the same is enforced in Antarctic and so the cost for cruising industry is already a bit smaller. If it applies for all ships then the freighters and tankers will have an increase at their fuel cost that might lead to nullification of any gains of the NSR and NWP in relation to traditional routes. The mechanism for spill management is already in place and will probably not need an upgrade and thus any cost cuts will come from the long term point of view and the intervention necessity frequency. The emissions quality and their impact on water acidification and ice coverage by black carbon thought will be virtually eliminated and with it the need of further regulatory provisions.

All in all the aspiration for a new merchant route, the small number of ship traveling the area and the already in place oil spill respond mechanism is prohibiting the ban of HFO in the region at least for now. The application of such a ban just for the cruising ships can be valuable but also not particularly necessary since the industry’s image and customers already demand and have “clean funnels”.

4.8. Noise emittions

STRENGTHS	WEAKNESSES
• Pre-emptive control of possible problem • Animal protection • Environmental sensitivity	• Avoidance of marine mammals areas already required • Improper understanding of sound propagation in ice covered waters
OPORTUNITIES	**THREATS**
• Enhance of ecosystem approach on environmental protection • Prove ecological sensitivities • Mitigation of need of future regulation	• Added navigational risk • Over regulation?

Another straight case: At one side the noise is a known issue, dead marine mammals are not what anybody wants to see and a pre-emptive move can save animals and regulatory effort later. On the other hand decreased efficiency navigational aids will hurt ship safety and our incomplete knowledge of the issue makes decisions ambiguous.

In hindsight everything might seems obvious, but currently simply not enough information and data are discovered or collected in order to make sound judgment upon.

4.9. Tourist shore landing access

STRENGTHS	WEAKNESSES
• Pre-emptive control of possible problem • Animal and plant protection • Environmental sensitivity	• Enforcement capability • AECO already has a member mandatory guideline. • Arctic Councils new guidelines
OPORTUNITIES	**THREATS**
• Enhance of ecosystem approach on environmental protection • Prove ecological sensitivities • Mitigation of need of future regulation • Preservation of tourist attractions.	• Over regulation • Enforcement cost • Landing control is virtually impossible

Landing rules are the most problematic to compose and enforce. For once the industry and its clients demand it, while on the other hand states do not have, or apply, the resources to monitor all of them. The good and bad part of the issue is that activities like that pose threats to both landing parties and animals so the cruise companies have some incentive to follow the guidelines. Some bad practices are observed from time to time –bear herding- but it seem not to be the norm. It is evident that no injuries have been reported so far so the main problem in this case would be fauna. Arctic plants are very fragile and the climatic conditions do not allow them to repair their damage as fast as lower latitude plants. That lead to loss of plant coverage and the ruination of the pristine “unexplored” feeling that visitors receive from their surroundings. On the part of migratory invasive species risk is also real and already proven. Thus the plethora of guidelines of different enforcement level introduced by government, industry organisations, national park authorities throughout the region. Enforcement is a serious problem though as in almost all the examined issues since effective policing seem to be an expensive issue. Further tight regulation on activities can not be advised under this scope. The limitation of total landings is next to impossible if the small craft traffic and local visitation of communities by cruise ships are factored in. It is not like the Antarctic that the traffic is very small and it is easy to impose such limitations.

It is considered advisable that any effort that would be applied to address this complicate problem should be focused on enforcement compliance to best practices, guidelines and local rules that are already in place since it seems that any regulatory effort will be an unnecessary, unenforceable attempt.

5. Polar Operational Limit Assessment Code

In the examination of the law framework and the existing regional issues, one abeyance distinguishes herself above all others: Risk assessment and mitigation. During SWOT analysis the Risk issue becomes abundantly profound and predominant, as it is the core factor that is considered by the regulators and constantly, through their regulation decisions, evaluated and mitigated.

The Marine Safety Comity worked for some time to compose the "Polar Operational Limit Assessment Risk Indexing System" or POLARIS for short, a yet incomplete part of section I-B of the Polar Code as described in IMO's MSC 94/3/7 and MSC 94/INF.13 documents. As its name makes abundantly clear it is a system intended to be used by the ships sailing in polar waters for planning a polar passage or for real-time assessment and decision making about shipboard operations when initially expected conditions are changing, and by administrations to set operational limitations for ships operating in ice infested waters. The system creation is based to the combined experience with three existing approaches: the Canadian Arctic, Baltic (Finnish/Swedish), and Russian Northern Sea Route systems. Identified key elements of the system are:

- Partial concentrations: Uniform ice conditions are a rarity and since the ice regime of an area contains multiple ice types the risk profile of the operating ships there is fundamentally altered.
- Summer/Winter conditions: Ice strength of several ice types and the corresponding load that is applied to a ship structure varies significantly throughout the year.
- Icebreaker Escort: Ice breaker supported operations have different Risk profiles since the ice is managed to an extent by the icebreaker and not entirely by the ship

5.1. POLARIS method

POLARIS is a method to calculate a Risk Index Outcome (RIO) value in order to assess ice based operational limitations in a region. The regional RIO value is calculated by adding together all RIO values for each of the ice regimes present in the area. The local RIO values are calculated by multiplying the ice concentration index with the Risk Index Value assigned to the ships ice class for the specific ice regime encountered. The formula is the following:

$$RIO = (C_1 * RIV_1) + (C_2 * RIV_2) + \cdots + (C_n * RIV_n) \quad [1]$$

Where:

- C_1 … C_n; represent the ice type concentration, in tenths as they are found in ice charts,
- RIV_1 … RIV_n; represent the Risk Index Values assigned to the ships ice class.

The following table presents the current Risk Index Values used for POLARIS RIO calculations.

	Ice Class	Ice Free	New Ice	Grey Ice	Grey White Ice	Thin First Year Ice, 1st Stage	Thin First Year Ice, 2nd Stage	Medium First Year Ice 1st Stage	Medium First Year Ice 2nd Stage	Thick First Year Ice	Second Year Ice	Light Multi Year Ice	Heavy Multi Year Ice
A	PC 1	3	3	3	3	2	2	2	2	2	2	2	1
	PC 2	3	3	3	3	2	2	2	2	2	1	1	0
	PC 3	3	3	3	3	2	2	2	2	2	1	1	-1
	PC 4	3	3	3	3	2	2	2	2	1	0	0	-2
	PC 5	3	3	3	3	2	2	2	1	0	-1	-1	-2
B	PC 6	3	2	2	2	2	1	1	0	-1	-2	-2	-3
	PC 7	3	2	2	2	1	1	0	-1	-2	-3	-3	-3
C	IA Super	3	2	2	2	2	1	0	-1	-2	-3	-3	-4
	IA	3	2	2	2	1	0	-1	-2	-3	-4	-4	-4
	IB	3	2	2	1	0	-1	-2	-3	-3	-4	-4	-5
	IC	3	2	1	1	-1	-2	-2	-3	-4	-4	-4	-6
	Not Ice Strengthened	3	1	0	-1	-2	-2	-3	-3	-4	-5	-5	-6

Figure 21: Risk Index Values relative to winter Ice Conditions and ships Ice Class (source: IMO MSC 94/3/7)

The POLARIS in its current iteration is using ice parameters for winter and summer conditions, when decay of ice due to warm weather conditions of spring and summer are altering the strength of some types of ice. Thus the bellow table represent the summer Risk Index Value.

	Ice Class	Ice Free	New Ice	Grey Ice	Grey White Ice	Thin First Year Ice, 1st Stage	Thin First Year Ice, 2nd Stage	Medium First Year Ice 1st Stage	Medium First Year Ice 2nd Stage	Thick First Year Ice	Second Year Ice	Light Multi Year Ice	Heavy Multi Year Ice
A	PC 1	3	3	3	3	2	2	2	2	2	2	2	1
	PC 2	3	3	3	3	2	2	2	2	2	1	1	0
	PC 3	3	3	3	3	2	2	2	2	2	1	1	-1
	PC 4	3	3	3	3	2	2	2	2	1	0	0	-2
	PC 5	3	3	3	3	2	2	2	2	1	-1	-1	-2
B	PC 6	3	2	2	2	2	1	2	1	-0	-2	-2	-3
	PC 7	3	2	2	2	1	1	1	0	-1	-3	-3	-3
C	IA Super	3	2	2	2	2	1	1	0	-1	-3	-3	-4
	IA	3	2	2	2	1	0	0	-1	-2	-4	-4	-4
	IB	3	2	2	1	0	-1	-2	-1	-2	-4	-4	-5
	IC	3	2	1	1	-1	-2	-2	-2	-3	-4	-4	-6
	Not Ice Strengthened	3	1	0	-1	-2	-2	-2	-2	-3	-5	-5	-6

Figure 22: Risk Index Values relative to summer Ice Conditions and ships Ice Class (source: IMO MSC 94/3/7)

The resulting RIO value assume as given the Mariners training, attention and the exercised caution to his ships operations when factors such as visibility and weather conditions are changing. The RIO value magnitude is checked against the following table in order to determine if the ships operations are permitted, limited, or prohibited.

RIO_{SHIP}	Category A & B (PC1 – PC7)	Category C (below PC7)
RIO ≥ 0	Operation Permitted	Operation Permitted
-10 ≤ RIO < 0	Limited Speed Operation Permitted (See Table 1.3)	Operation Not Permitted
RIO < -10	Operation Not Permitted	Operation Not Permitted

Figure 23: RIO evaluation criteria for independent operations (source: IMO MSC 94/3/7)

In the case that the ship is escorted by an icebreaker when the fairway created by the assisting ship is wider than the beam of the assisted ship, and taking under account the above mentioned considerations the RIO estimation is as follows:

- The Icebreaker estimates her RIO_{SHIP} (=$RIO_{ICEBREAKER}$), for the course plotted and compare the result against the independent operations table in order to estimate if it is able to complete the trip.
- Then the Icebreaker estimates the $RIO_{ESCORTED}$, for the ship she is providing her escort service and compares the results against the escort operations table.
- The escorted ship estimate her own $RIO_{ESCORTED}$ based on the ice regime the icebreaker will encounter and compares the results against the escort operations table.
- Finally the escorted ship estimate her own RIO_{TRACK} (=RIO_{SHIP}) based on the ice regime she will travel behind the Icebreaker escort and compare the result against the independent operations table. If actual floes are less than 2 m in diameter, consider it "brash" with an RV equivalent to Ice Free. This step may be omitted at voyage planning stage.

In the case that the fairway created by the assisting ship is not wider than the beam of the assisted ship then the $RIO_{ESCORTED}$, is evaluated against the independent operations table.

The RIO evaluation criteria table for Escorted operations is as follows:

RIO_{SHIP}	Category A & B (PC1 – PC7)	Category C (below PC7)
RIO ≥ 0	Operation permitted	Operation permitted
-10 ≤ RIO < 0	Limited speed operation permitted (See table 1.3)	Operation not permitted
RIO < -10	Operation not permitted	Operation not permitted

Figure 24: RIO evaluation criteria for ships escorted by Ice-Breaker (source: IMO MSC 94/3/7)

Finally the proposed section I-B of the Polar Code make provisions for the case of ships that are equipped with ice load measurement and monitoring systems or ships that have completed full scale ice trials that are allowed to calibrate safe operating speeds based on the following table:

Ship category (ice class)	Independent operation speed (knots)	Escorted operation speed (knots)
A (PC1 – PC2)	NA	NA
A (PC3 – PC5)	5 knots	5 knots
B (PC6 – PC7)	3 knots	3 knots
C (IA Super - IA)	NA	3 knots
C (below IA)	NA	NA

Figure 25: Marginal capability speed limitations (source: IMO MSC 94/3/7)

5.2. Case description

To try and understand better the mechanics of the POLARIS and its application on real life scenario, the decision was made to calculate a paradigm scenario. For that purpose there was not a better subject for examination than the ship which planned trip sparked the idea for this study. The ship structure is known and the Canadian Arctic through which it will sail in summer of 2016 is an extremely well-studied are for its ice conditions and the information about it historical and current are readily available for the public. Furthermore the time window for the voyage is known, between 16th August and 17th September of 2016, so the focus can be placed to a particular body of ice carts and data.

Figure 26: Crystal Symphony programmed route (source: Crystal Cruises, voyage brosure, 2015)

The time table of the trip is as in the following table provided by Crystal Cruises in the voyage online brochure:

VOYAGE 6319 | 32 DAYS | AUGUST 16, 2016

NORTHWEST PASSAGE

SEWARD TO NEW YORK CITY | CRYSTAL SERENITY

DATE	DAY	PORT	ARRIVE	DEPART
Aug 16	Tue	**Anchorage/Seward, Alaska, USA***		9 pm
Aug 17	Wed	Kodiak, Alaska, USA	9 am	6 pm
Aug 18	Thu	*Cruising North Pacific Ocean*		
Aug 19	Fri	Dutch Harbor, Alaska, USA	8 am	6 pm
Aug 20	Sat	*Cruising the Bering Sea*		
Aug 21	Sun	Nome, Alaska, USA ✪	10 am	11 pm
Aug 22	Mon	*Cruising the Bering Sea*		
Aug 23	Tue	*Cruising Little Diomede Island, Alaska, USA*		
Aug 24	Wed	*Cruising the Chukchi Sea*		
Aug 25-26		*Cruising the Beaufort Sea*		
Aug 27	Sat	Ulukhaktok, Northwest Territories, Canada ✪	8 am	6 pm
Aug 28	Sun	*Cruising Dolphin & Union Straits*		
Aug 29	Mon	Cambridge Bay, Nunavut, Canada ✪	7 am	7 pm
Aug 30	Tue	*Cruising Victoria Strait*		
Aug 31	Wed	*Cruising Bellot Strait*		
Sep 1	Thu	*Cruising Peel Sound*		
Sep 2	Fri	*Cruising Beechey Island & Radstock Bay*	6 am	6 pm
Sep 3	Sat	*Cruising Croker Bay*	8 am	6 pm
Sep 4	Sun	Pond Inlet, Nunavut, Canada ✪	6 am	6 pm
Sep 5	Mon	*Cruising Baffin Island Fjords*		
Sep 6	Tue	*Cruising Davis Strait*		
Sep 7	Wed	*Cruising Disko Bay*		
		Ilulissat, Greenland ✪	7 am	6 pm
Sep 8	Thu	Sisimiut, Greenland ✪	8 am	4 pm
Sep 9	Fri	Nuuk, Greenland	7 am	4 pm
Sep 10-11		*Cruising the Labrador Sea*		
Sep 12	Mon	*Cruising the Atlantic Ocean*		
Sep 13	Tue	Bar Harbor, Maine USA	9 am	6 pm
Sep 14	Wed	Boston, Massachusetts, USA	8 am	6 pm
Sep 15	Thu	Newport, Rhode Island, USA	10 am	5 pm
Sep 16	Fri	New York City, NY, USA (overnight)	9 am	
Sep 17	Sat	**New York City, NY, USA**	Disembark am	

✪ Maiden Call

*Transfer from/to Anchorage included.

Arrival and departure times will depend on tides, weather, ice and wildlife opportunities. All itineraries are subject to change.

Figure 27: Time table for NWP voyage 2016 (source: Crystal Cruises, voyage brosure, 2015)

Under this scope what follows is the presentation of ice charts, ice data, and prediction of conditions for western Canadian Arctic and the calculations of Crystal Symphony's POLARIS based RIO value for solo navigation.

5.3. Ice Regime

5.3.1. General

Canadian Ice Service operates a web portal that makes available all the historical and current ice charts, ice reports and all studies conducted by or for the Service. Thus the following charts and conclusions are based to the Sea Ice Climatic Atlas for the Northern Canadian Waters 1981-2010 and the yearly reports of 2011 to 2014.

Historically the ice conditions vary wildly 1983 was the year of max extent of ice and 2010 the minima. Due to climatic / atmospheric variations such differences can be observed on year by year basis but in some cases even in weekly base. Also last year’s conditions can have lingering effects for the ice regime of the next year as it defines the second year ice amount that will mix with the new ice. In some cases currents, of both air and water, moved ice that broke up in the previous summer kept it from melting entirely and when the freeze up begun altered greatly the local ice regime dramatically. For further information on ice coverage see Annex II.

Ice thickness varies by area but generally do not exceed 2.4m except in the cases of ice-self fragments that can be up to 20m thick they consist of fresh-water and sea-water ice and formed near the Ellesmere Island over many years.

5.3.2. Canadian West Arctic

The ship is expected to enter Baffin Sea at 25th of August and make two calls to port in Ulukhaktok, Northwest Territories, Canada and Cambridge Bay, Nunavut, Canada. By the 3rd of September the ship will have cross the Barrow Straight and will be in Canadian East Arctic.

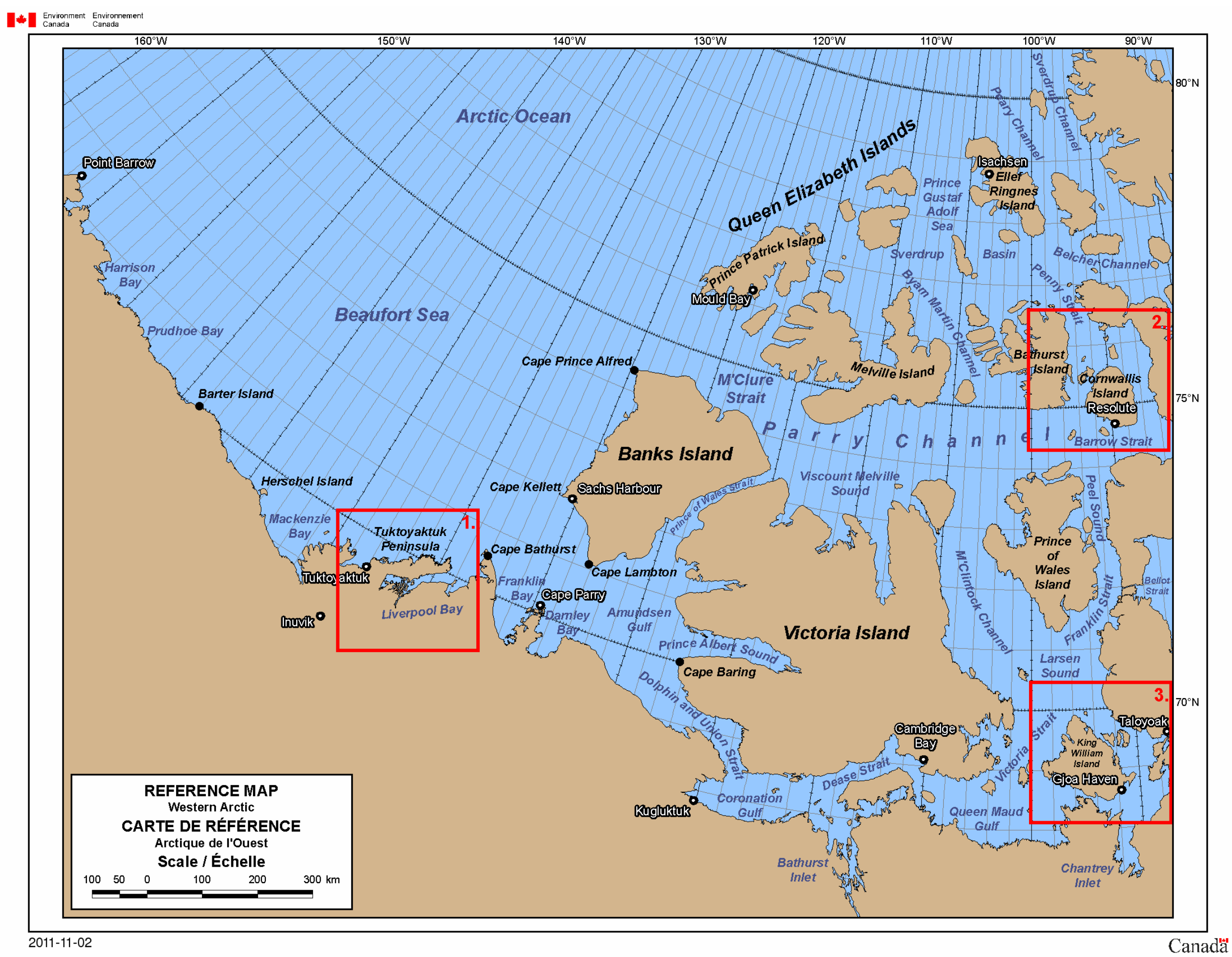

Figure 28: Canadian West Arctic reference map (source: CIS, www.ec.gc.ca, 2015)

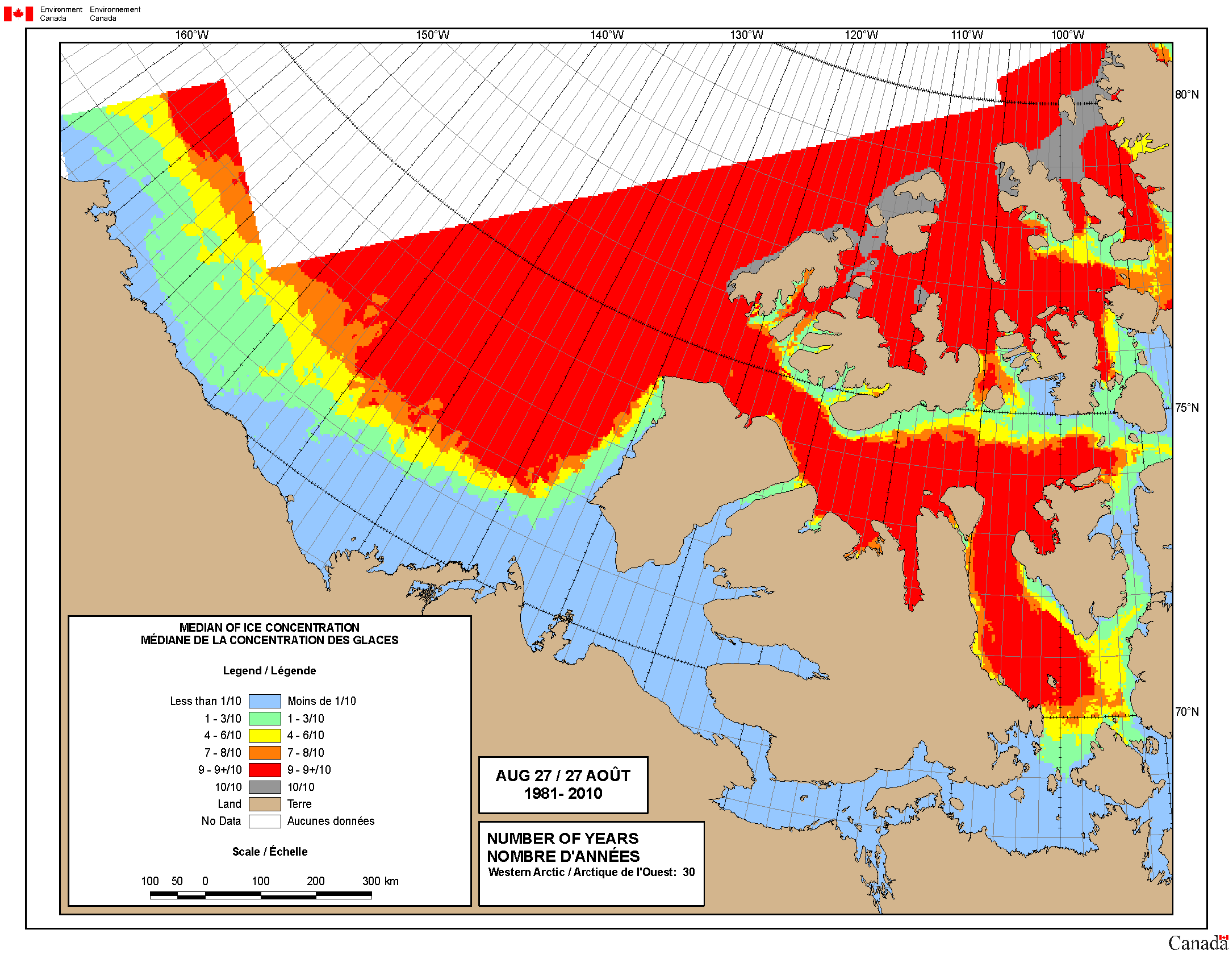

Figure 29: Ice concentration from1981 to 2010 for week of 27/8 to 3/9 (source: CIS, www.ec.gc.ca, 2015)

Studying the above and following maps someone will see that only small differences can be observed in the ice concentration charts implying the a slight decline of regime severity, consistent with the graphs in Annex II. The ship will not have to face any ice if will remain in a safe distance from the concentrations defined by weather and current information available. When will reach the Victoria Strait and start cruising north to reach the Barrow Strait, the last 4 days of this time frame, it will be forced to navigate through ice regimes reaching 9/10 concentration. That is because the since the summer of 2013 it is observed only partial melting of the local ice and thus the ice there is getting older and moving towards the south end of the NWP.

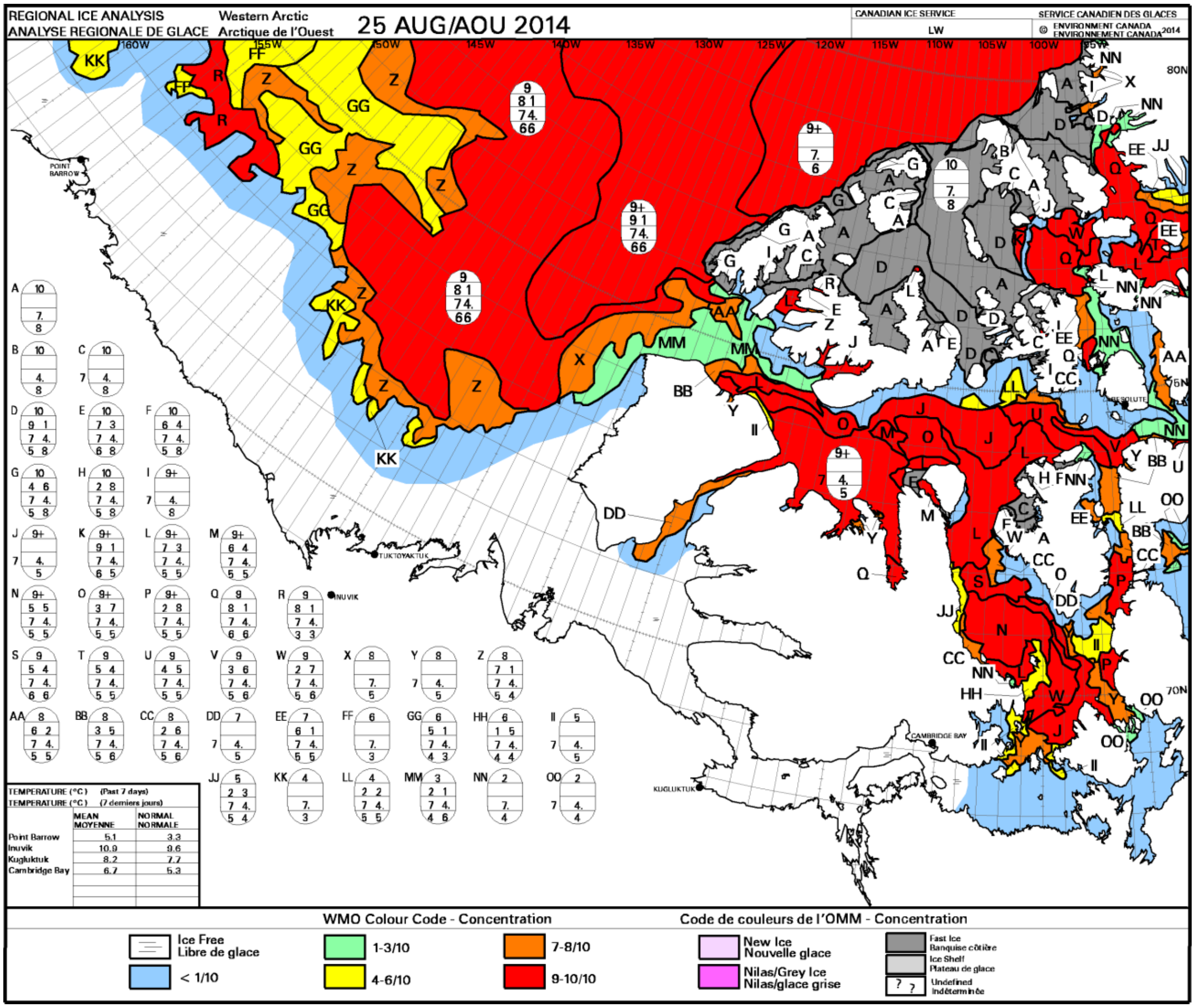

Figure 30: Ice concentration for week of 27/8 to 3/9 of 2014 (source: CIS, www.ec.gc.ca, 2015)

5.3.3. Canadian East Arctic

The ship is expected to enter the region through the Barrow Strait cruising towards Pond Inlet of Nunavut, Canada, at the first days of September and making a call to the port there at the 4th of the month. Pont Inlet is located in the South part of Bylot Island inside reference area 4 in the following map.

The ice regimes expected there are ranging widely from open water up to 8/10, but probably there will be able to plot a route through only up to 4-5/10 areas and only at the exit area of Barrow Strait. The rest of the trip is open water, but attention and alert would be advisable for iceberg and ice-self fragments from Ellesmere Island.

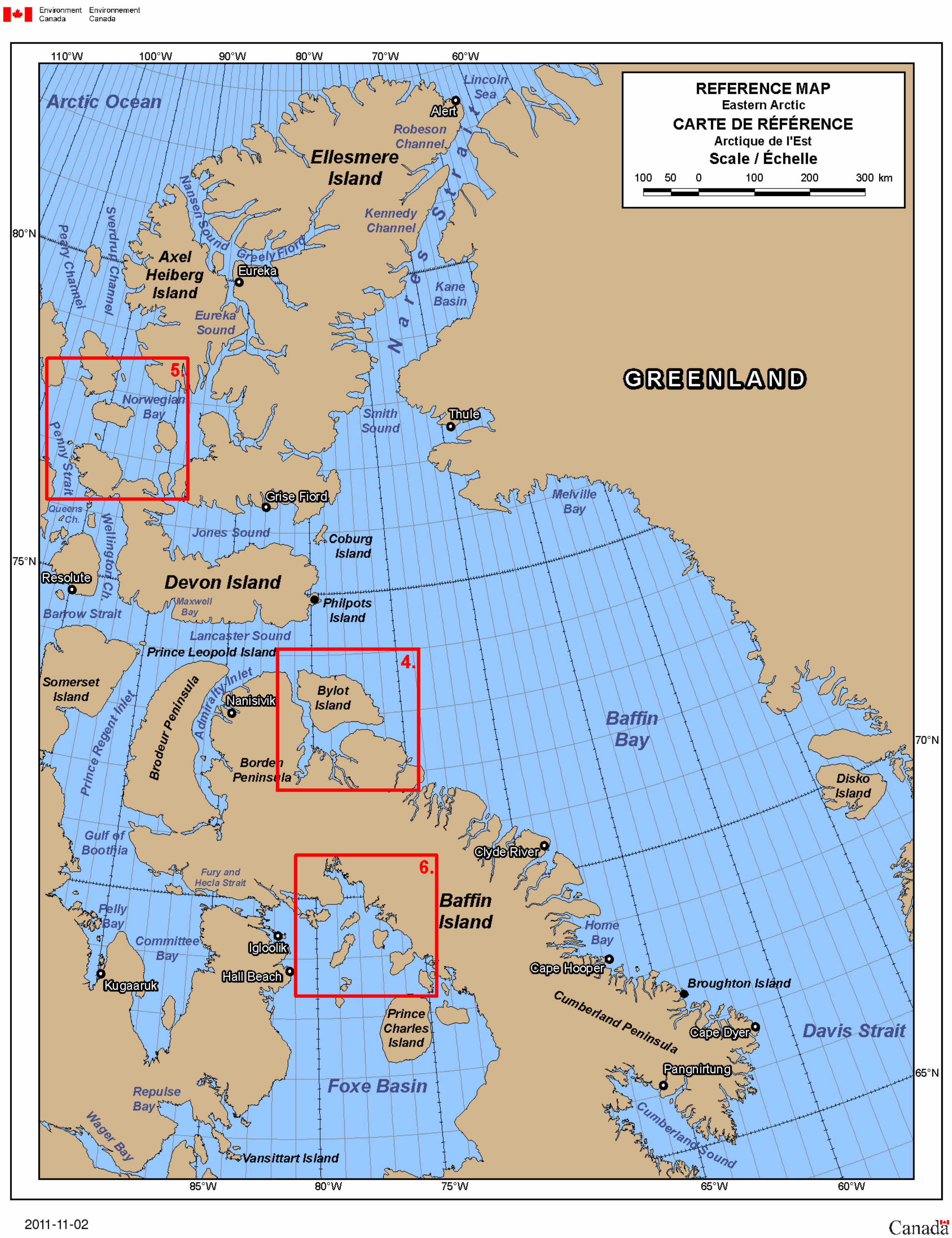

Figure 31: Canadian East Arctic reference map (source: CIS, www.ec.gc.ca, 2015)

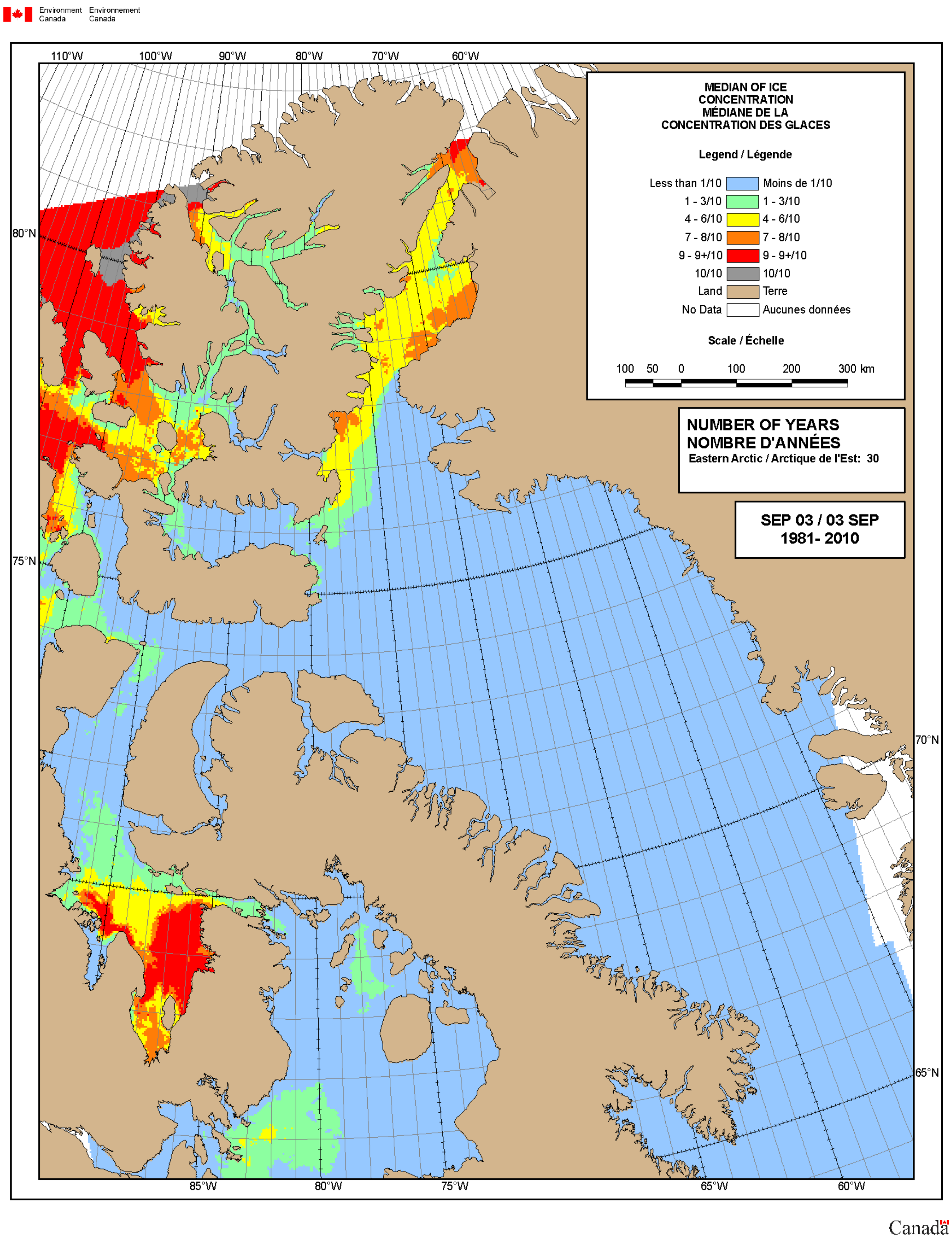

Figure 32: Ice concentration from1981 to 2010 for week of 3/9 to 10/9 (source: CIS, www.ec.gc.ca, 2015)

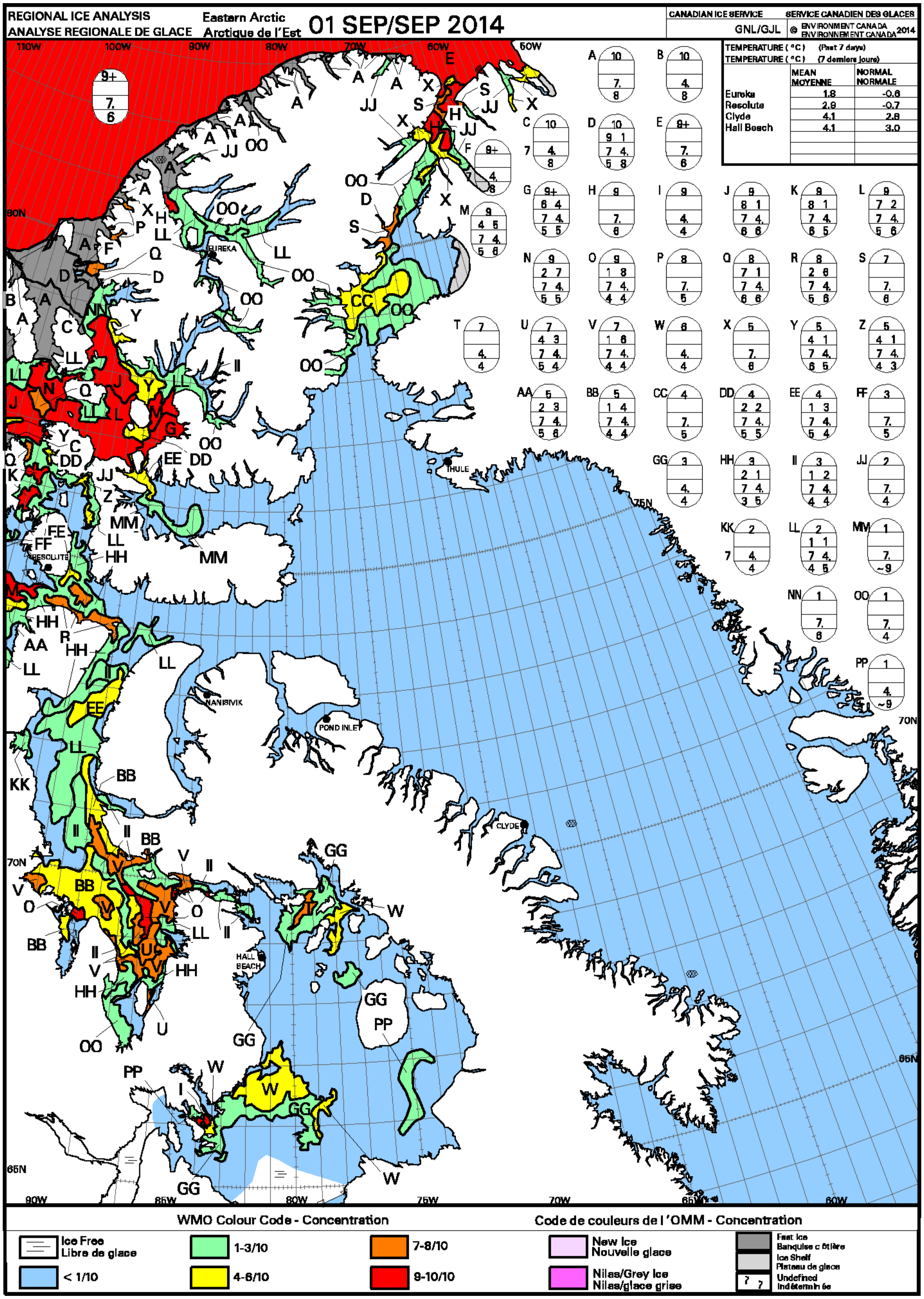

Figure 33: Ice concentration from1981 to 2010 for week of 3/9 to 10/9, 2014 (source: CIS, www.ec.gc.ca, 2015)

The ice charts make use of the “Egg Code” to describe the particular areas ice regime, the “eggs” are situated in a convenient part of the map. The International System of Sea Ice Symbols or the “Egg Code” is a product of the World Meteorological Organization (WMO) Working Group on Sea Ice attempt to develop an international ice code as well as standard symbols to represent ice, and it is meant for use on synoptic and prognostic ice charts produced by national ice centers. The WMO instructions of how to wright and read the egg code are located in Annex III.

For all the information the CIS makes available through they do not provide any type of prediction for the coming ice regime in any form (chart or general description). Furthermore the intricacies of the ice cycle in the Canadian Arctic is unknown to the author and thus cannot create a predictive model, not to mention that this is beyond the scope of this work. Thus the decision was made to use for the calculations of the paradigm scenario the detailed ice charts of 2014 for the following reasons:

- The ice conditions in the NWP Canadian Arctic region do not appear to fluctuate significantly in year to year bases. Any significant changes are happening over medium to long time-frames.
- Any change in the ice regime can usually be traced in previous years variations of ice cycle.
- The general qualities of the ice regime do not appear to be significantly different from the studied 30 year median.
- Extent of ice coverage is largely consistent due to the Archipelago geographical and climatological factors.

5.4. Operational capability estimation

The programed course of the ship would have passed through the following types of concentrations as they can be read from “eggs”, the egg like bubbles of numerical information in the charts legend, the ice charts:

- In the Canadian West Arctic ice chart the course develop through: II, Y, J, W, N, DD, P, CC, LL, EE, V, and NN.
- In the Canadian East Arctic ice chart the course develop through: AA, and HH.

For example, II ice regime is translated as: 5/10 concentration of Thick First Year Ice (>120 cm)in the form of Big Ice Floe (500 m - 2 km)with traces of less than 1/10 concentration of First Year Thin Ice (30 - 70 cm).

That corresponds in:

$C = 5$

$RIV = -3$ (From figure 22 value for no ice class ship in thick first year ice)

So the Risk value for the ship in the map area with the mentioned type of ice regime (II) will be:

$RIO_{II} = C * RIV = 5 * -3 = -15$, NO GO for the ship as per figure 23 criteria for independent operations.

The remaining detailed calculations can be seen in Annex IV. The results are summarised in the following table.

Region by ice regime code	RIO value	Average
II	-15 NO GO	-19.6
Y	-24 NO GO	
J	-27 NO GO	
W	-25 NO GO	
N	-25 NO GO	
DD	-21 NO GO	
P	-28 NO GO	
CC	-22 NO GO	
LL	-10 NO GO	
EE	-15 NO GO	
V	-24 NO GO	
NN	-4 NO GO	
AA	-18 NO GO	
HH	-16 NO GO	

Figure 34: Risk calculation results summary.

The average Risk value is 19.6; this is almost double the acceptable upper limit for sailing under limited speed when the ship is fully ice tested (in this case it is not). It is evident, that as it was expected the Crystal symphony would have to be escorted by one or two ice breakers, depending on the ice breakers beam, in case of encountering any of the ice regimes mapped in the CIS ice charts. Furthermore according to the proposed regulation 1.5.1.4 of the IMO MSC 94/3/7, the ice breaker escort would have to provide a fairway wide enough and with an ice regime that is equivalent to the Risk provided by "Grey ice" or lower in order for the ship to be safe to sail properly, fairways with ice floes smaller than 2m in diameter are considered brash ice and have an RIV equivalent with "ice free" regime. Otherwise the proposed regulation is forcing the ship captain and the Ice breaker captain to compare the RIO results of their calculations for the escorted ship with the independent operations table which result in forbiddance of operations (fact partially irrelevant since class C ships have the same results in the RIO evaluation tables).

From the calculations can be derived also the advisable minimum ice strengthening class that the ship should have been in order to achieve independent operations Risk evaluation. The most influential to the RIO value ice regime was that of “thick first year ice”, offering a steady -3 factor throughout the calculation, while also having the biggest concentration factors. An ice class that can reduce or eliminate its negative impact to the RIO calculations would be an ice class designation of at list 1A Super and optimally a PC6.

6. Summary and Conclusions

The Arctic region is an ecology and climate wise important and sensitive region of the planet, with continuous presence of hardy human populations that through the millennias of their habitation have found the best practices for living in the Arctic. The global changes are affecting the region on all levels its inhabitants are attempting to adapt and exploit their resources in order to better their life importing southern luxuries and new type of economic activities, while keeping their cultural identity.

Maritime activities such as oil prospecting and production, shipping and cruise have become far easier and more profitable In the last 30 years and they fundamentally reforming the region economically, culturally and technologically, with speeds probably not seen since the expansion of European colonies towards the west coast of North America and the Pacific Coast of Asia.

Nowadays it seems widely acceptable that such activities and their impacts (good or bad) have to be harnessed under sufficient regulation in order to protect the Arctic environment and through it the global one, and the regions inhabitants interests and global heritage. Tourism and cruising in particular under this purview are capable to act as a low intensity industry that can further the interests of every stakeholder in the region if it is conducted with sufficient oversight.

Cruising and tourism come with a number of issues that are based on human relations and plenty of issues that are directly linked to the technologies that allow them to be possible in the first place. The mere presence of a ship in any waters have the same challenges, the difference is the elevated risks stemming from the particular climate and access difficulties of the Arctic region. Under this scope and throughout this study the related to Cruising Tourism regulatory abeyances were examined and the conclusions are to be presented in this section.

6.1. Ship Structure

The harmonization of law and unification of ice class systems are a big step forward for the shipbuilders and operators, as chronic ambiguity is finally addressed. The new rule framework still have some gaps intended to allow older ships to continue operate in the waters they were designed for and as their fleet replacement will eventually come faze out. Regulations do not need further changes but meticulous enforcement to prevent other unsafe ships to exploit the gap. In that spirit, the paragraph in the polar code that provide for relaxed or at list opportunistic inspections should be amended despite it only affects Class C cargo ships. Furthermore there have to be better defined icing stability provisions.

Proposal

Part I-A Regulation 1.3.3 of the RESOLUTION MSC.385 (94) INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS (POLAR CODE) should be change to:

"For category C cargo ships, if the result of the assessment in paragraph 1.5 is that no additional equipment or structural modification is required to comply with the Polar Code, the Polar Ship Certificate may be issued based upon documented verification that the ship complies with all relevant requirements of the Polar Code. In this case, for continued validity of the certificate, an on board survey should be undertaken at the last port called by the ship before entering Polar waters."

6.2. PWOM quality assurance

That document is the "playbook" of the ship in ice infested waters. Documents of similar function that all ships are obliged to have for sailing in any sea had in the past many cases quality issues the lead to accidents and loss of ship, cargo and life. That is of further interest for ice infested waters that the risks are much higher and the resources available for responding to crises are far limited in comparison. The experience deficiency of flag state authorities in formatting and inspecting such documents must be bridged by adoptions of quality standards in the image of crew training qualifications and relegation of inspection authority by states that cannot enforce them (flag of opportunity states).

6.3. Bird Colonies protection

Arctic birds have common habitats and living areas with the sea mammals in a percentage that exceed 95%, only five (5) colonies are detached. Birds are sensitive to noise and other disturbances, they are important part of the arctic environment and should be protected. The current regulation protect them sufficiently by proxy, and it is a political issue to make there protection status official. The changes required to regulations are minimal.

Proposal

If so decided, Part I-A Regulations 11.3.6-7 of the RESOLUTION MSC.385 (94) INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS (POLAR CODE) should be change to:

".6 current information and measures to be taken when marine mammals are encountered relating to known areas with densities of marine mammals and Arctic bird colonies, including seasonal migration areas;

.7 current information on relevant ships' routing systems, speed recommendations and vessel traffic services relating to known areas with densities of marine mammals and Arctic bird colonies, including seasonal migration areas;"

6.4. Ballast water

Ballast water disposals are the most common way that invasive alien spices are migrating around the globe. Arctic Ocean is a bridge between Pacific and Atlantic Oceans and ships cruising in both can be used for summer cruises in the Arctic, multiplying the range of possible invading organisms. The new BWM convention will solve major part of the problem if it is finally come to be implemented. For that extra global fleet votes are needed and further regulation at list at this point is pointless.

6.5. Garbage and sewage dumping

Waste management in the Arctic is a technically challenging task because of the weather conditions that promote preservation and expensive because the population centres are small, and isolated from the necessary resources. If we further focus on ships we will also see that traffic and ports are relatively small despite the latest explosion of interest and voyages. Narrowing the spectrum further into cruising ships there evidence that waste products from cruise ships is much more dangerous that from other ships. Non mandatory best practice rules and local law are protecting to a certain degree the environment of the harm such by-products are causing but it is also statistically evident that there is a repeat violation culture to some operators that addressing the fines as operating cost in the region. High seas resemble the Wild West in this matter. The already existing good will by industry should be further promoted and re-enforced and a change to the existing provisions should be made to ban any disposal in the region. Such a development can lead to the creation of waste management services in some ports in the arctic region creating a new revenue stream for the local governments or entrepreneurs.

Proposal

As far as sewage is the matter of regulation:

In the case of regulating only cruising ships because of their higher Risk factor Part II-A Regulation 4.2.2 of the RESOLUTION MSC.385 (94) INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS (POLAR CODE) should be change to:

"4.2.2 Discharge of sewage into the sea is prohibited from category A and B ships constructed on or after [date of entry into force], and all passenger ships, except where it would unduly impair Arctic operations and when such discharges are in compliance with paragraph 4.2.1.3 of this chapter."

In the case of general regulation affecting all ships the same then Part II-A Regulation 4.2 of the RESOLUTION MSC.385 (94) INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS (POLAR CODE) should be change to:

"4.2 Operational requirements

4.2.1 Discharges of sewage within polar waters are prohibited except where it would unduly impair Arctic operations and when such discharges are in compliance with paragraph 4.2.1.1 of this chapter.

1. the ship has in operation an approved sewage treatment plant20 certified by the Administration to meet the operational requirements in either regulation 9.1.1 or 9.2.1 of MARPOL Annex IV, and discharges sewage in accordance with regulation 11.1.2 of Annex IV and shall be as far as practicable from the nearest land, any ice-shelf, fast ice or areas of ice concentration exceeding 1/10.

As far as garbage is the matter of regulation the Arctic should be declared a Special Area and be included to the relevant garbage disposal regulations of Regulation 5 of MARPOL Annex V. In the case it is decided that just passenger ships will be affected by further restriction of garbage disposal then paragraph can be added before Part II-A Regulation 5.2.3 of the RESOLUTION MSC.385 (94) INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS (POLAR CODE) stating that:

"Discharge into the sea is prohibited from all passenger ships, of all plastics, including but not limited to synthetic ropes, synthetic fishing nets, plastic garbage bags, and of all other garbage, including paper products, rags, glass, metal, bottles, crockery, incineration ash, dunnage, lining and packing materials."

6.6. HFO

The Arctic and its two main water ways NSR and NWP are promoted for merchant shipping purposes between Asia and major Atlantic ports. Such type of ships use HFO in order to be cheap and profitable in their operations and under that scope it is counter intuitive to ban the usage of that fuel type in the region, despite that is a very noxious substance and the cold climate that prevent rapid dilution make it even more dangerous. Some countries have ban it for their waters and more could follow but that is not an issue for cruising industry that have a ban of use by AOR members and generally use diesel for "clean funnels".

The actual discussion in the topic should be the emissions impact to the acidification of Arctic waters and the actual effect of the black carbon emitted by the ships to the ice cycle. Both of the issues are currently not sufficiently studied and thus no conclusions can be drawn.

6.7. Noise

Our knowledge of how sound propagate in a sea with ice cover is well studied, as well studied is the effects of a change on vital rates to the animal (fish, sea mammal) populations. What there is little knowledge about are the mechanisms that govern the cause and effect cycle that links the noise of ships to the marine animal population issues. This knowledge gap should be filled before we draw conclusions and respond accordingly.

6.8. Landings

Cruise ship tourist landings is an issue that the industry should take it more seriously than at the moment and coordinate with local environmental and cultural authorities in order to make them as much non-invasive and not disruptive for fauna flora and indigenous people as possible. General regulation such as the existing in Antarctic treaty is not possible for the most part of the region but others (Antarctic Treaty: Annex II article 3, Annex III article 1, Annex V article 8) can be guidelines if not adopted for usage in Arctic by Arctic states in a form of Arctic Tourism Treaty. What can be immediately demanded is proper decontamination procedures so invasive species cannot be spread, and maybe a limit of landings of tourist on the ice self if this is beneficial. Other measures should be adopted for the other zones such as inspections of threatened areas and a rotation system of landing zones that will be open or close to away parties based on preservation principals. It would beneficial for the cruise ships and their companies and the Arctic the locals and the environment since it will maintain the “unspoiled unexplored” feeling for the tourist, help nature maintain her vigour and distribute the tourist income to the whole region. Such initiative though would need: some resources that should burden the tourist or the companies and a far better coordination with the local communities than the already existing.

Regulation wise it would not be beneficial in any way an Antarctic like status for the Arctic except the mentioned necessity to examine the benefits of an ice-self landing control.

6.9. POLARIS

The POLARIS is an important tool that can actually mitigate a large number of dangers provided that the bridge crew of the vessels are sufficiently trained but it has its own shortcomings. Ice regime might be indeed be mild and operation for any subject ship might be permissible but often other parameters can inhibit operations or even make them impossible. An example coming from personal experience, wind can pack ice that however thin and weak it might be can stop an otherwise capable ship. Second, as the Ice classification system for the ships is ignoring the ships engine power the POLARIS is also, inherently, ignoring that parameter. Finnish experience have proved that insufficient engine power can render an otherwise sufficiently ice strengthen ship helpless under pack ice conditions. Last but not list is the issue of how the possibility of decisions made motivated by interest (company's, ship's or captain's) are to be encouraged to be avoided, and if still made how will be punished.

7. Further studies proposal

During the studies connected to this body of work several knowledge deficiencies were spotted in several knowledge fields.

- First of them all spotted that there are no historical data about the thickness of the ice cover of Arctic. Lately a small scale submersible data research was funded but as the polar ice is recognised as a crucial factor for global climate that type of data should be collected more rigorously.
- Partial ice conditions temporal and geographic extent, and composition quality features should be studied like the extent and quality of the Arctic ice cover.
- Staying in the polar ice subject, the voyages through the polar areas are almost always planned quite some time in advance, months and in some cases years, and even then their success cannot be guaranteed since the unpredictability of yearly ice regime is evident. Never the less, areas like NSR and NWP are monitored for decades and have a wealth of historical data. A statistical at first prediction system might be possible that could be then evolve to a more dynamic form taking in account the current data stream from observations that the local services collect for producing the ice charts.
- The biologist also have a lot of blind spots: microorganism studies must become a focus since is the only categories that we do not have any information about its biodiversity, the fish species population health must be evaluated, the mechanisms that govern the cause and effect cycle that links the noise of ships to the marine animal population issues must be understood. All of them are important so we can make informed decision of how Arctic species can be protected by the inevitable human activity.
- Despite the increased interest there is a dig deficiency of understanding the native populations, their history, culture, and their interaction with natural resources should be further studied in cooperation with native scholars, their cultural and archaeological sites identified and catalogued. That will provide a clearer pattern for the human populations global expansion, we can finally have a complete list of sites of interest to pay proper attention to, and will promote a more honest, informed and productive cooperation of local communities with the “southerners”.
- The socioeconomic impact of Arctic tourism in general and cruising tourism in particular to native population and culture.
- Air emittions specialists and oceanographers should investigate the exact impact of black carbon and ship air emittions have to the acidification of Arctic Ocean and the Arctic ice cover.
- The unification of all data bases, academic and commercial (shipping traffic data) regarding the Arctic should be further promoted in order to expedite research activities. Arctic Council might be in a unique position to create an academic research data centre.

- Comprehensive study of Arctic technology: History, usage and design evolution of ice breakers; changes in the Arctic marine technology of commercial ships and how these changes may influence the future of Arctic marine transport system.
- Comparative research about the expected quality issues with PWOM to other similar certification and procedure documentation issues in the past.
- Research on a unified marine traffic monitoring system for all Arctic and the corresponding navigational and position report aids.
- Interdisciplinary qualitative analysis of cruise ship sewage and the effectiveness of their sewage treatment plants.
- Development of touristic or otherwise, landing monitor system and their effects.
- POLARIS should also be further developed and verified by data of ice tests in scale, sea trials and real world data.

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vity+Databases&source=bl&ots=LjcOeZXd5s&sig=SoaqjWIzqzGAr_kEtTD2fwvEQP0&hl=el&sa=X&ei=SPi0VJa8FKmfygP41oKABg#v=onepage&q=Marine%20Activity%20Databases&f=false, [Accessed: 8th April 2015].

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archive%2Fcategory%2F505-working-groups%3Fdownload%3D2075%3Apame-arctic-shipborne-tourism-initiative-draft-work-plan&ei=aHNcVfGLG8S8swG-iYHYAQ&usg=AFQjCNF0a_RTl8AQ_RZRciSNjhHFH2kWrQ&sig2=rmbOXsQUAO2KMZlRwdtBmA&cad=rja [Accessed: 21st November 2014].

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Annex I

Category	Activities/pressures	Impacts
Pollution	Accidental discharge of oil and toxic chemicals	Physical oiling and death of birds and fur-bearing mammals due to impaired thermal insulation Toxicological effects
	Regular discharges to water (including garbage and illegal discharges)	Oiling (primarily from illegal discharges) Entanglement of whales and other wildlife (ropes, nets and other garbage) Ingestion of plastics by birds and mammals
	Emissions to air	Climate change (carbon dioxide and other greenhouse gases) Ozone and haze (nitrogen oxides) Decrease in local air quality Deterioration in ice conditions (black carbon; 'soot')
Disturbance	Sound and noise disturbance	Disruption of feeding, breeding or other vital activities for birds and mammals Interference with communication among whales
	Ice breakers and disturbance	Effects on behavior and communication between mammals Disturbance of wintering, migrating or staging birds and mammals in leads and polynyas Disruption of migration routes for terrestrial mammals crossing sea ice (e.g., caribou) Ice entrapment of whales in artificial leads
	Vessel strikes	Injury and death of whales by collision
	Light disturbance	Injury and death of birds attracted to lighted ships
Introductions	Introduction of invasive species through ballast water, hull fouling and cargo	Various biological and ecological effects including detrimental changes to foodwebs and displacement and potential loss of native species. Impacts on breeding birds by introduced predators, notably 'rat spills' associated with ship accidents on islands

Figure 35: Overview of environmental impacts associated with Arctic marine shipping. Source: based on (PAME, 2009).

Area type	Group/species	Sensitivity	
		Oil spill	Disturbance
Fish			
Spawning	Small cods spawning in winter under ice (Arctic cod, polar cod, navaga, saffron cod)	High	Low
	Demersal spawners (capelin, Atlantic and Pacific herring, Pacific cod)	Moderate to High	Low
	Pelagic spawners (Atlantic cod, walleye pollock, Greenland halibut)	Moderate to Low	Low
Nursery	Pacific salmons, eulachon, coregonid whitefishes	Moderate	Low
Migration	Arctic char	Low	Low
Wintering	Pacific herring, capelin	Moderate/Low	Low
Birds			
Spring staging	Seabirds (thick-billed and common murres, little auk, black guillemot, glaucous gull, ivory gull)	High	High
	Seaducks (common, king, spectacled and Steller's eiders, long-tailed duck, scoters)	High	High
	Divers or loons (red-throated, Arctic, Pacific, great northern, white-billed)	High	High
	Shorebirds (red-necked and red phalaropes)	High	High

Area type	Group/species	Sensitivity	
		Oil spill	Disturbance
Breeding	Seabirds (colonial breeders, including thick-billed and common murres, little auk, least, crested and parakeet auklets, black-legged kittiwake, northern fulmar, and others)	High	High to Moderate
	Seaducks (common eider)	High	High to Moderate
	Shorebirds (spoon-billed sandpiper)	High	High to Moderate
Feeding	Seabirds (non-breeding and post-breeding concentrations, including thick-billed and common murres, little auk, least, crested and parakeet auklets, black-legged kittiwake, short-tailed shearwater, short-tailed albatross)	High	Moderate to Low
	Seaducks	High	Moderate to Low
	Divers or loons	High	Moderate to Low
Molting	Seabirds (thick-billed and common murres)	High	High
	Seaducks (common, king, spectacled and Steller's eiders, long-tailed duck, scoters)	High	High
	Geese (brent, barnacle, emperor, cackling, white-fronted, pink-footed, snow)	High to Moderate/ Low	High to Moderate/Low
Autumn staging	Seabirds (thick-billed and common murres, others)	High	High
	Seaducks (common, king, spectacled and Steller's eiders, long-tailed duck, scoters)	High	High
	Geese (brent, barnacle, emperor, cackling, white-fronted, pink-footed, snow)	High	High
	Shorebirds (red-necked and red phalaropes, others)	High	High
Wintering	Seabirds	Moderate to Low	Moderate to Low
	Seaducks	High to Low	High to Low
	Geese	Moderate to Low	Moderate to Low
Mammals			
Migration	Bowhead, beluga, narwhal, walrus (spring migration)	High	High
	Seals (spotted, ribbon, harp)	Moderate/Low	Moderate/Low
	Polar bear	High	Moderate/Low
	Baleen whales (blue, fin, sei, humpback)	Low	Moderate/Low
Breeding	Bowhead, beluga, walrus (spring migration)	High	High
	Seals (ice-breeding species - harp, hooded, spotted, ribbon)	High	High
	Ringed seal	Moderate	Moderate/High
	Seals (harbor, gray)	Moderate	Moderate/Low
Feeding	Bowhead, beluga, narwhal, walrus	Moderate/Low	High/Moderate
	Polar bear	High	Moderate/Low
	Right whales (Atlantic and Pacific)	Moderate/High	High
	Baleen whales (blue, fin, sei, humpback)	Low	Moderate/Low
Resting	Walrus (haul-outs on ice and land)	Moderate	High/Moderate
	Seals (harp, hooded, spotted, ribbon, harbor, gray)	Moderate	Moderate/Low
Wintering	Bowhead, beluga, narwhal, walrus	High	High
	Seals (ice-associated - harp, hooded, spotted, ribbon)	Moderate	Moderate

Figure 36: Ecological use of areas by groups and/or species of fish, birds and mammals, and the associated sensitivity to oil spills and disturbance from shipping. (AMSA IIC, 2013)

‘Low’ indicates possible effects on individuals (but not enough to be significant at the population level); ‘High’ indicates possible effects at the population level, while ‘Moderate’ indicates possible but generally limited effects at the population level

Annex II

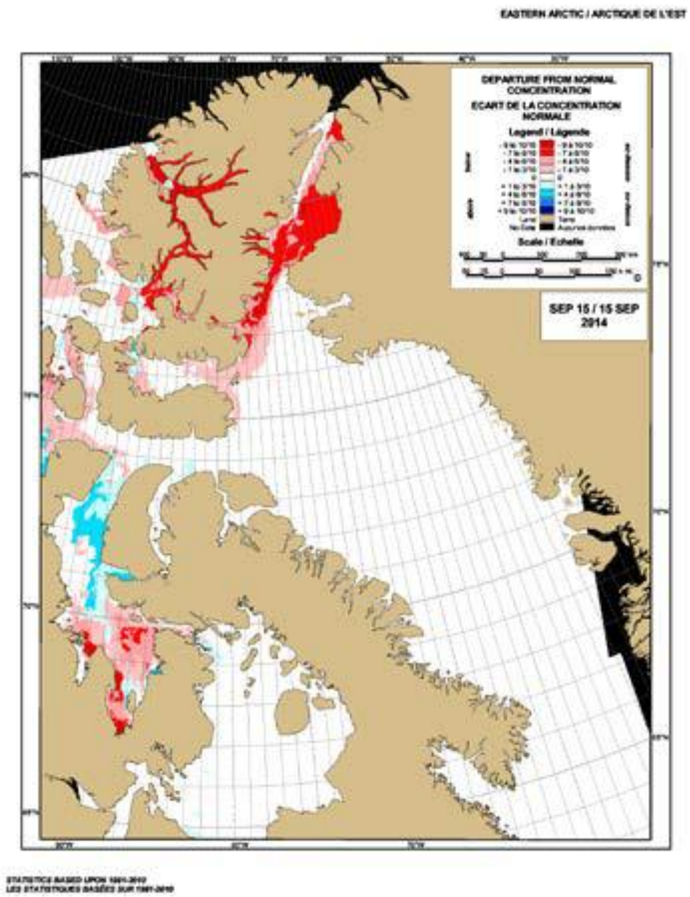

Figure 37: Departure from normal ice for the Eastern Arctic near mid-September 2014 (source: CIS, www.ec.gc.ca, 2015)

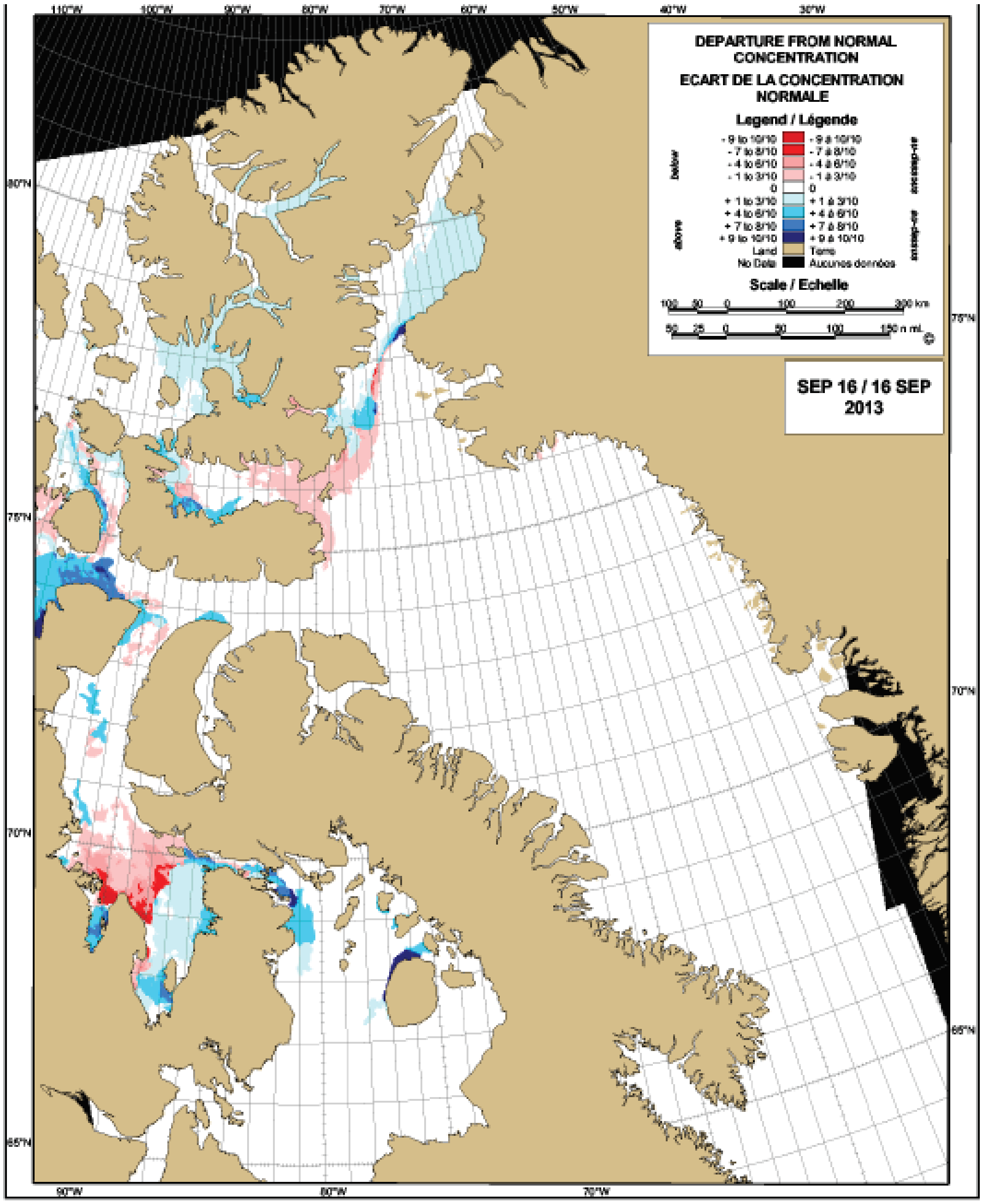

Figure 38 Departure from normal ice for the Eastern Arctic near mid-September 2013 (source: CIS, www.ec.gc.ca, 2015)

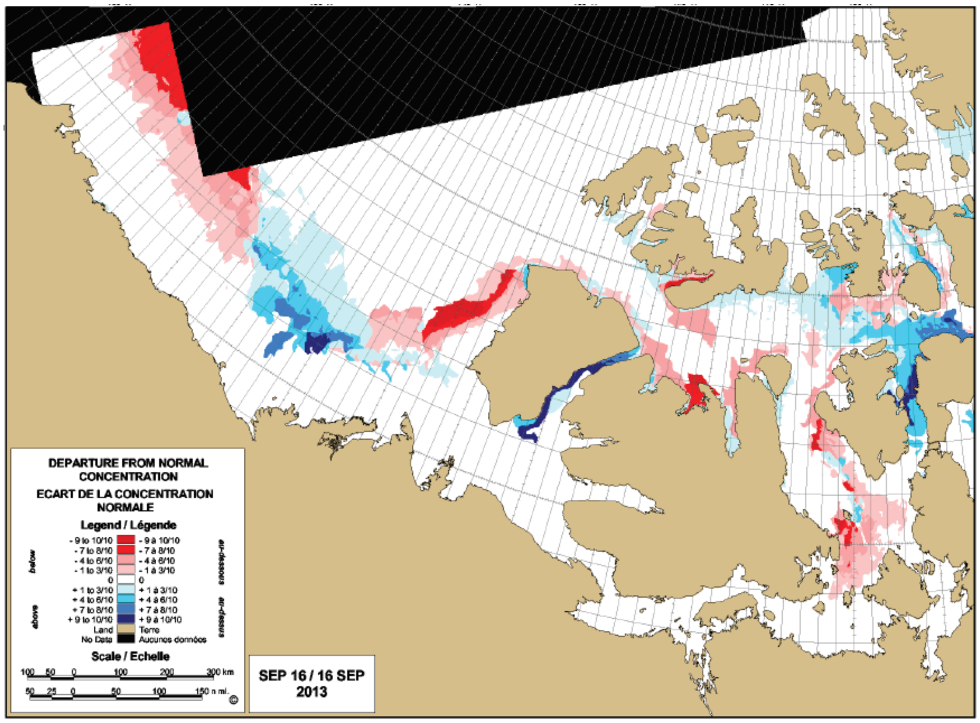

Figure 39 Departure from normal ice for the western Arctic near mid-September 2013 (source: CIS, www.ec.gc.ca, 2015)

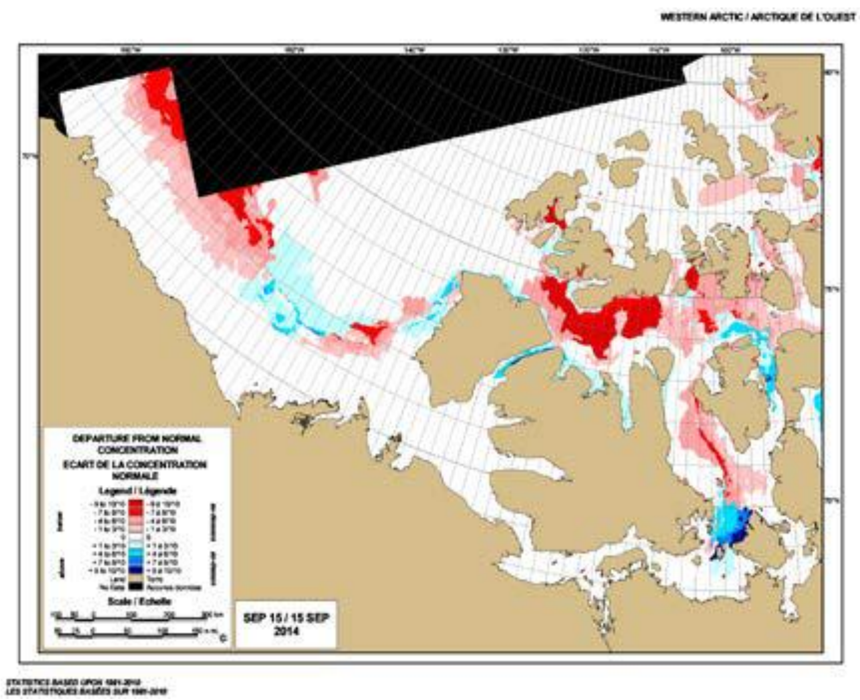

Figure 40 Departure from normal ice for the western Arctic near mid-September 2014 (source: CIS, www.ec.gc.ca, 2015)

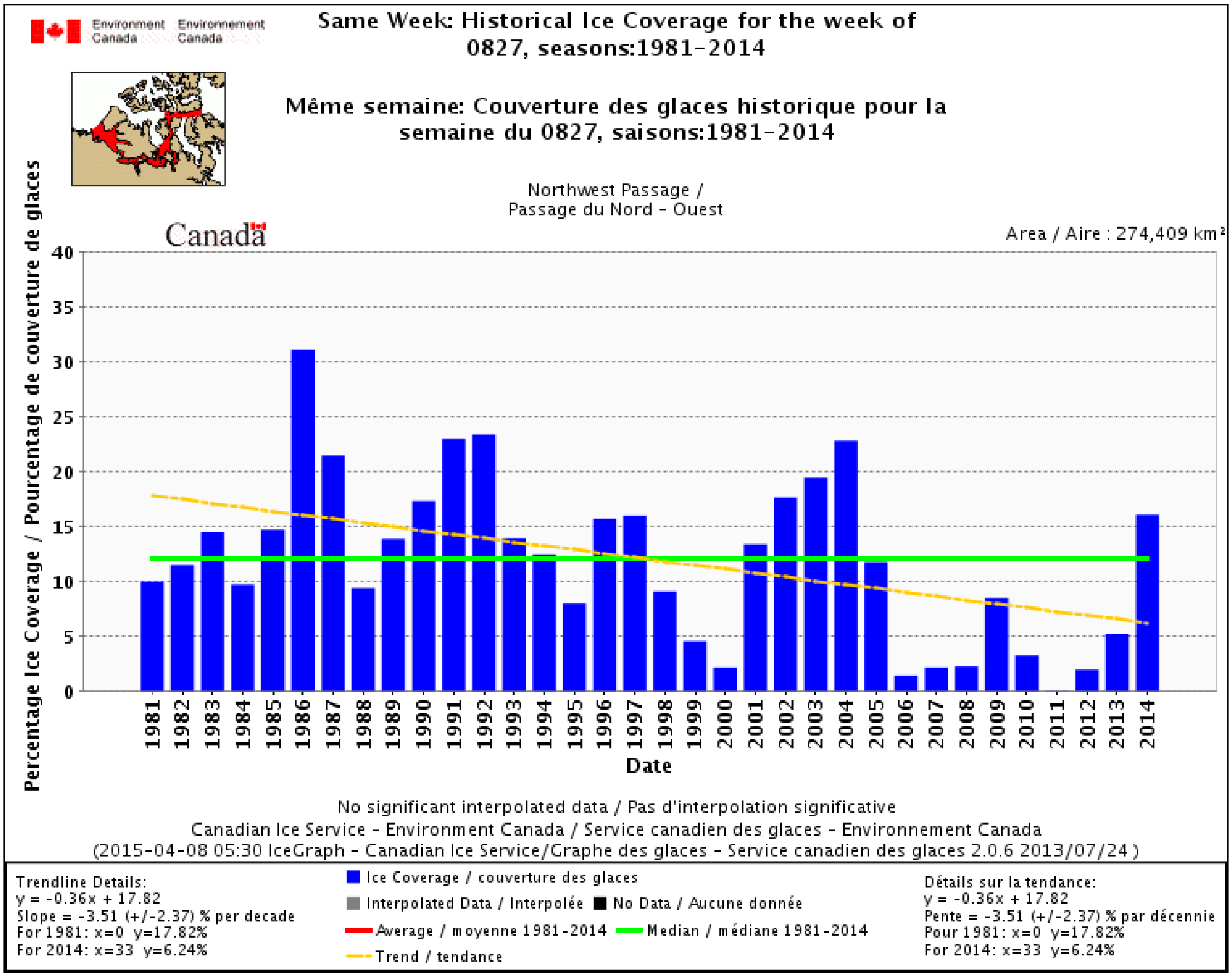

Figure 41: Historical ice coverage for the week of 08/27, seasons: 1981-2014 (source: CIS, www.ec.gc.ca, 2015)

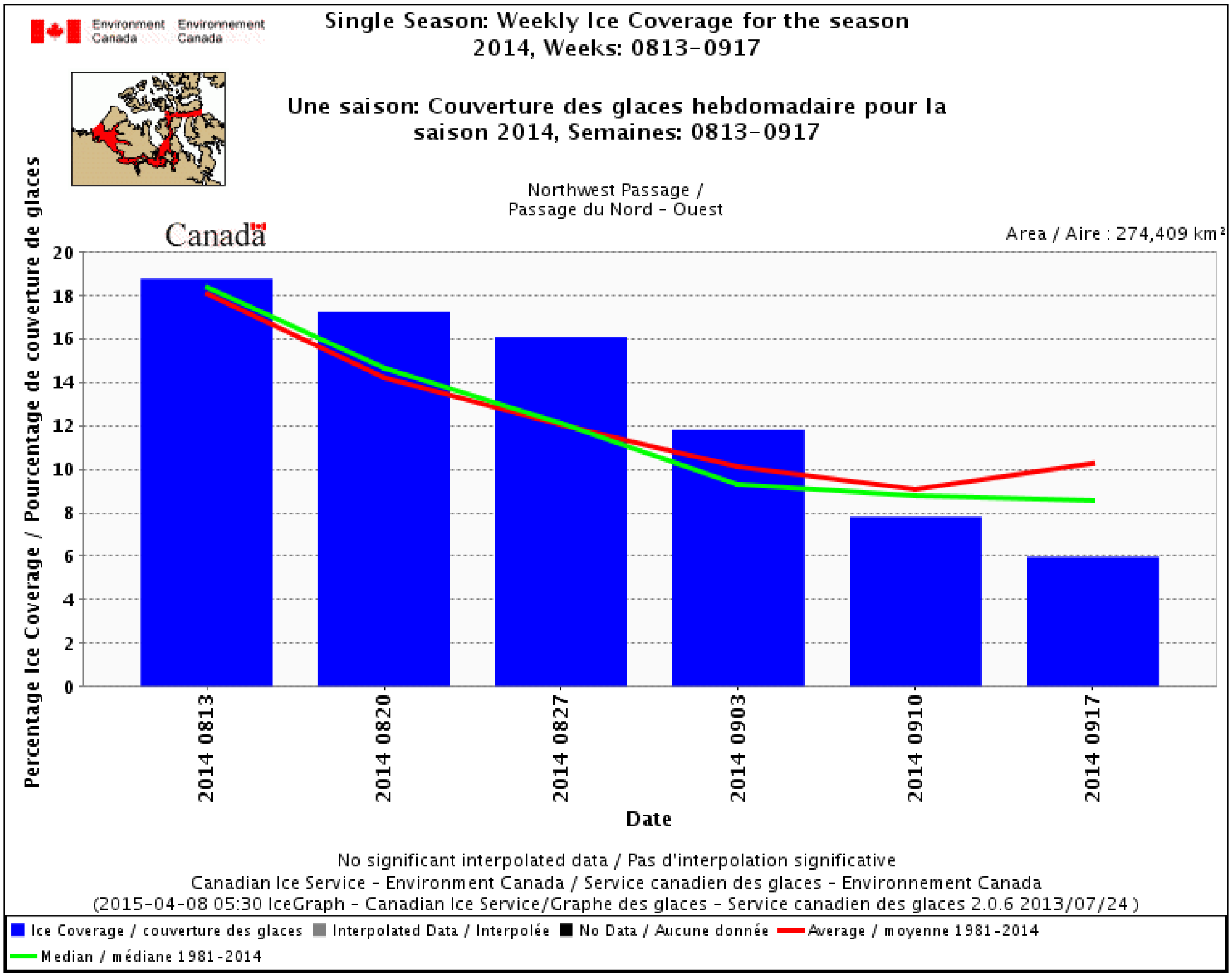

Figure 42: Single season weekly ice coverage for the season 2014 weeks: 08/13-09/17 (source: CIS, www.ec.gc.ca, 2015)

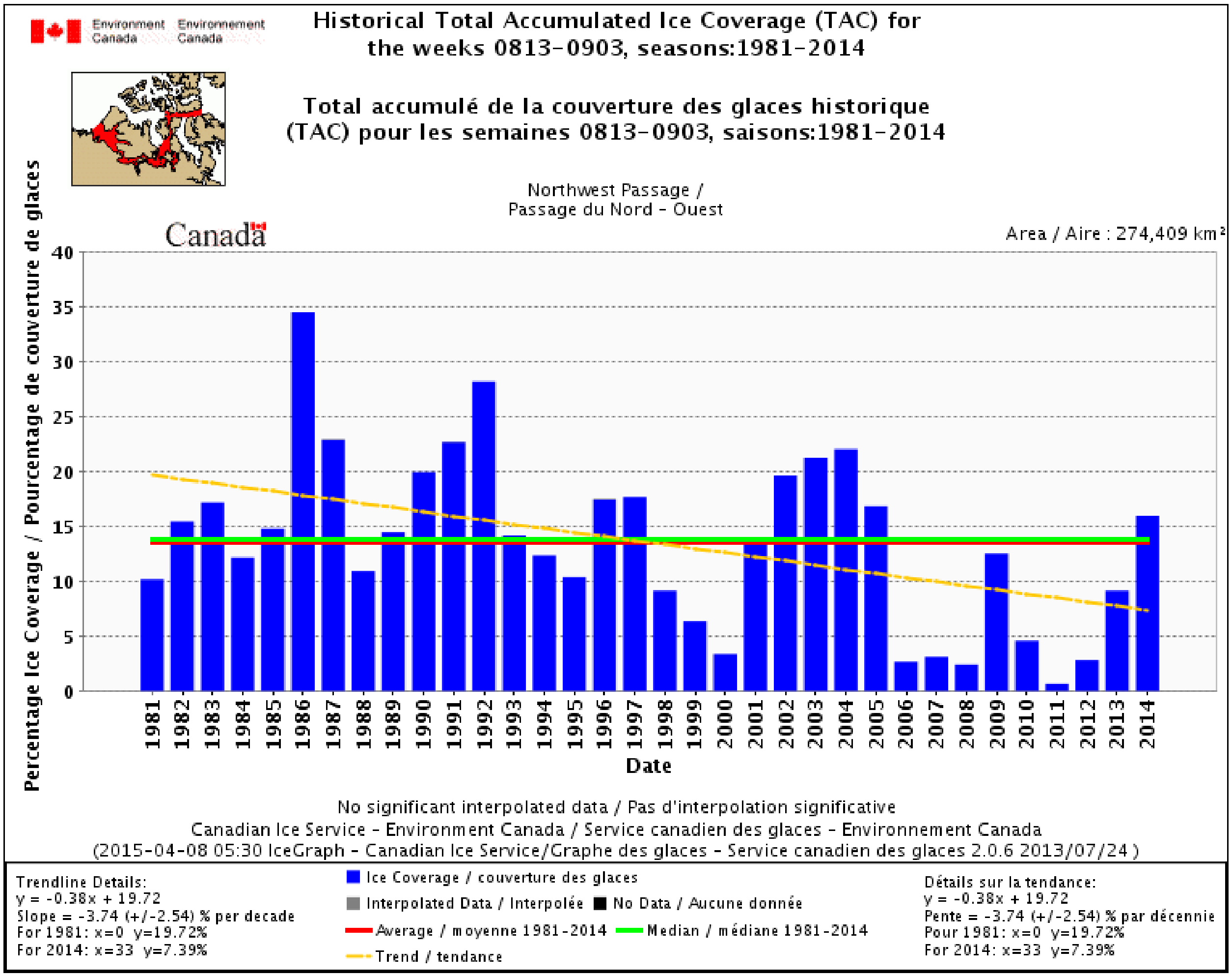

Figure 43: Historical total accumulated ice coverage for weeks 08/13-09/03, seasons: 1981-2014 (source: CIS, www.ec.gc.ca, 2015)

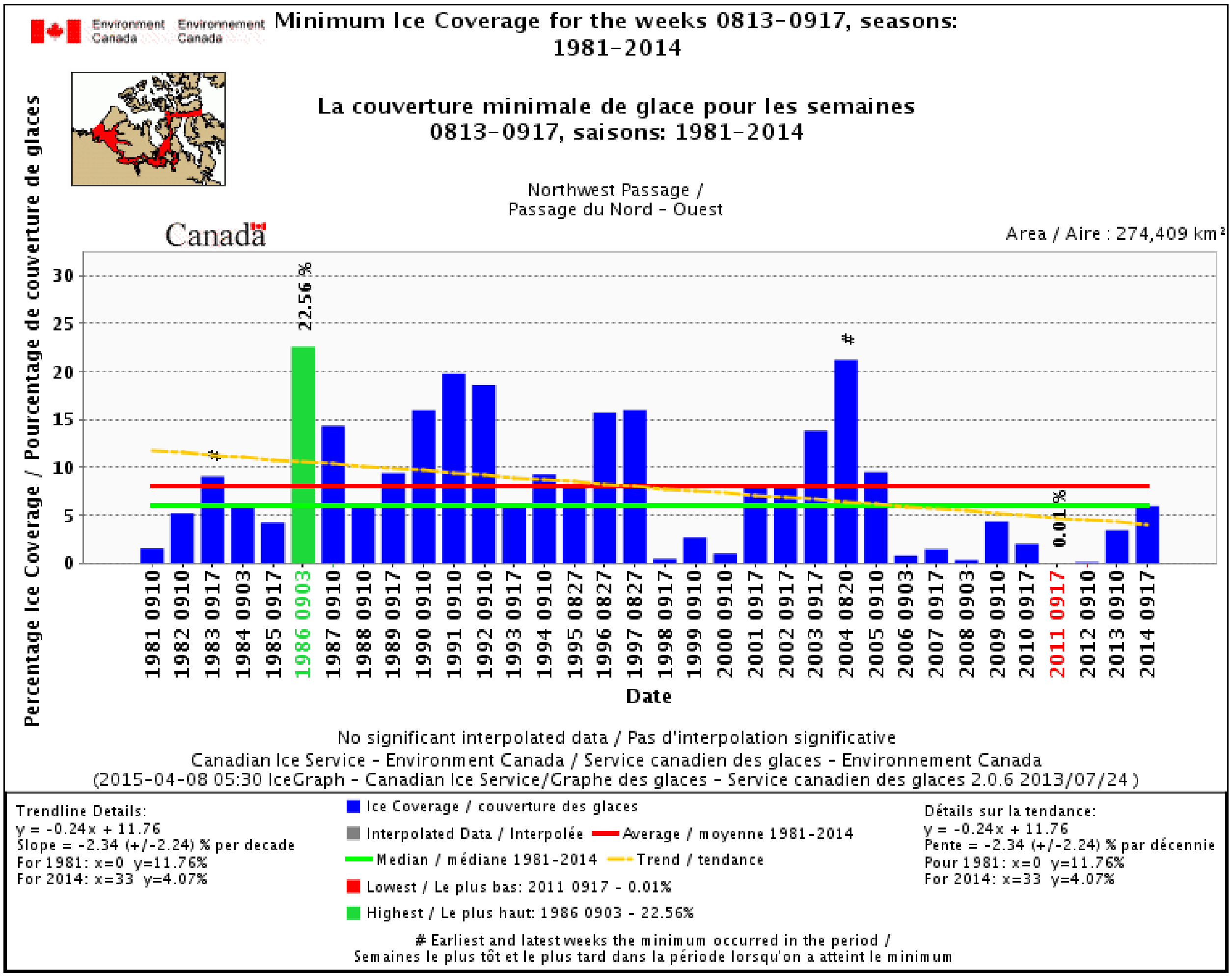

Figure 44:Minimum Ice Coverage for weeks 0/13-09/17, seasons:1981-2014 (source: CIS, www.ec.gc.ca, 2015)

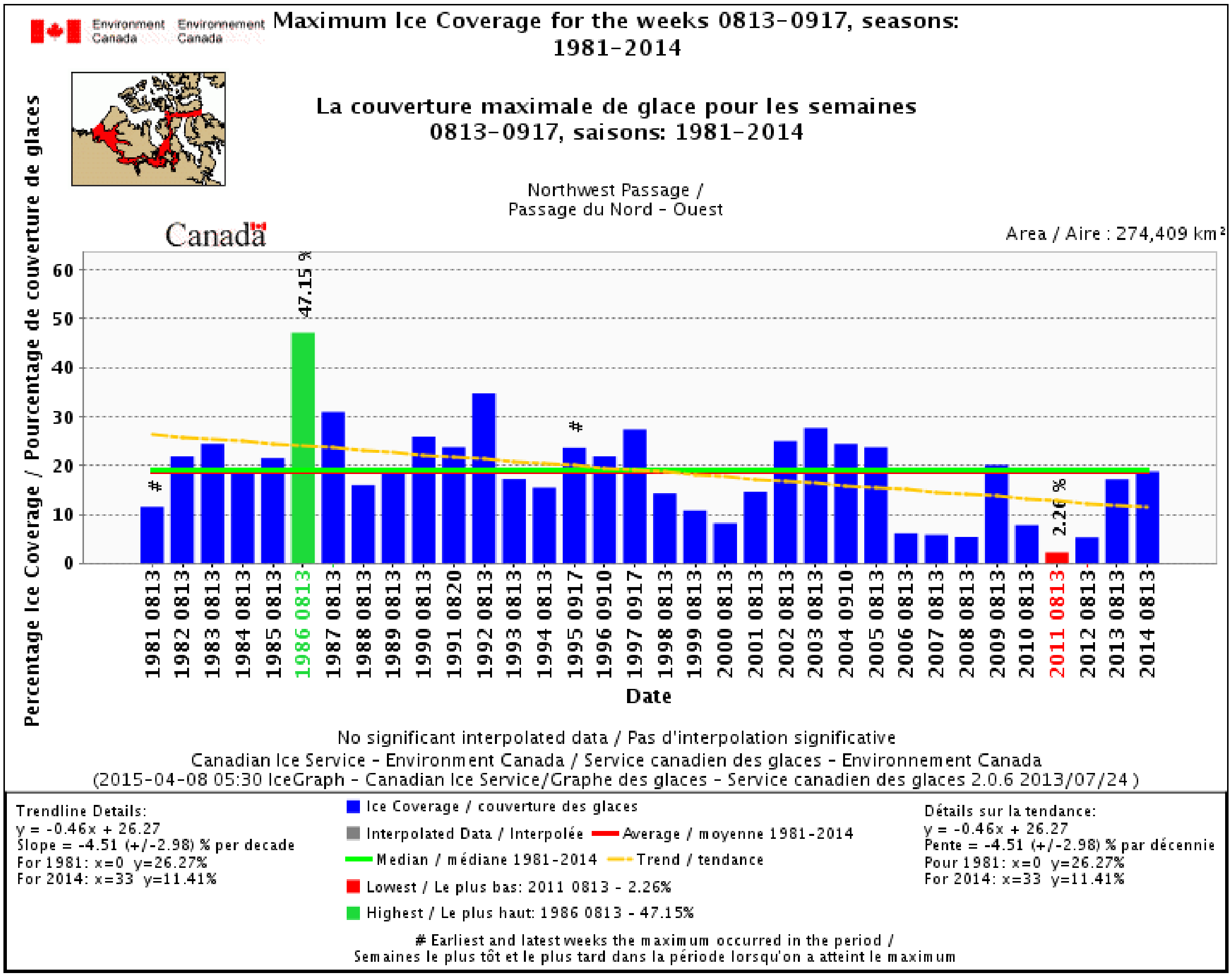

Figure 45:Maximum Ice Coverage for weeks 0/13-09/17, seasons:1981-2014 (source: CIS, www.ec.gc.ca, 2015)

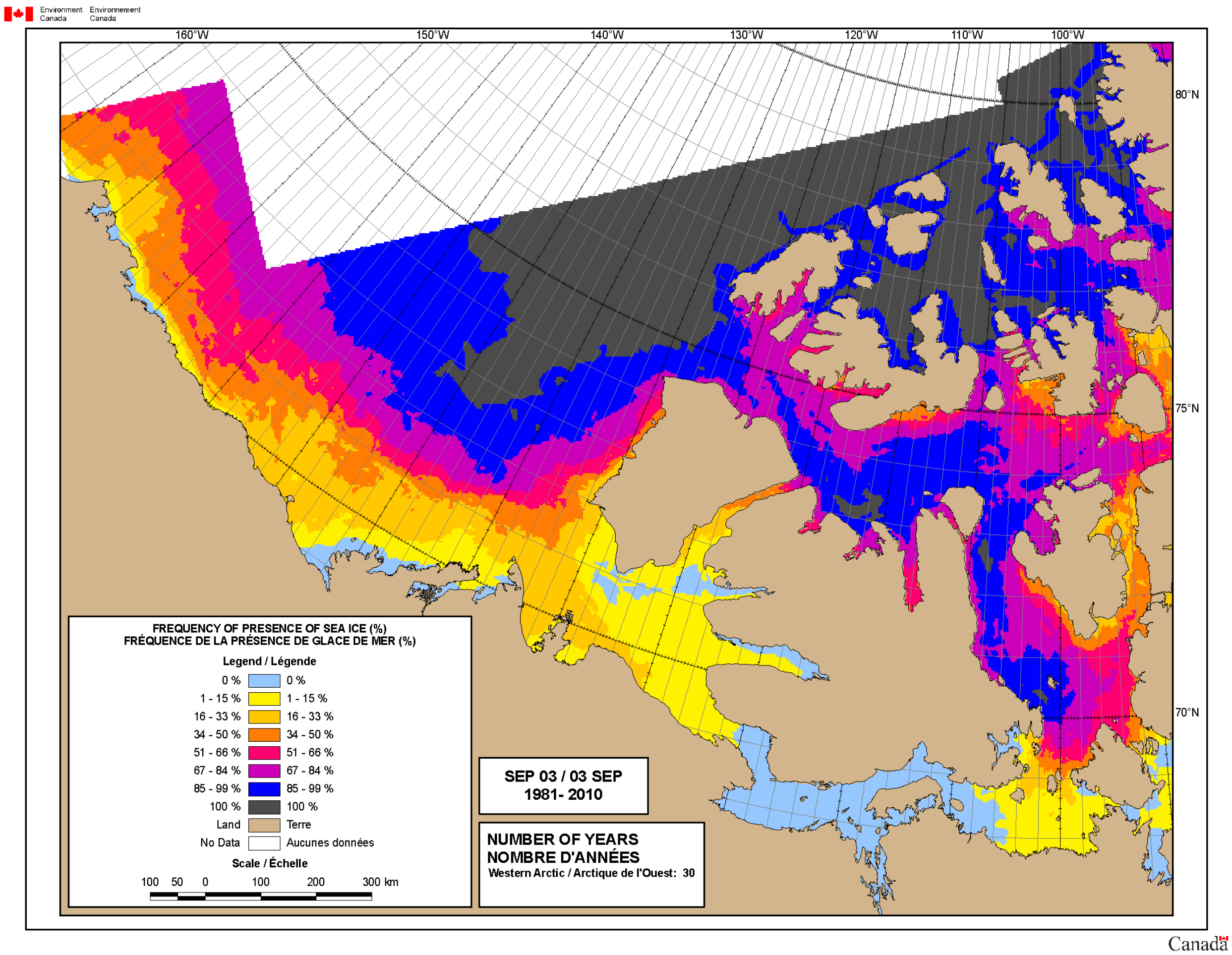

Figure 46: Map of historic frequency of sea ice presence in western Canadian arctic region for the week 09/03 seasons:1981-2014 (source: CIS, www.ec.gc.ca, 2015)

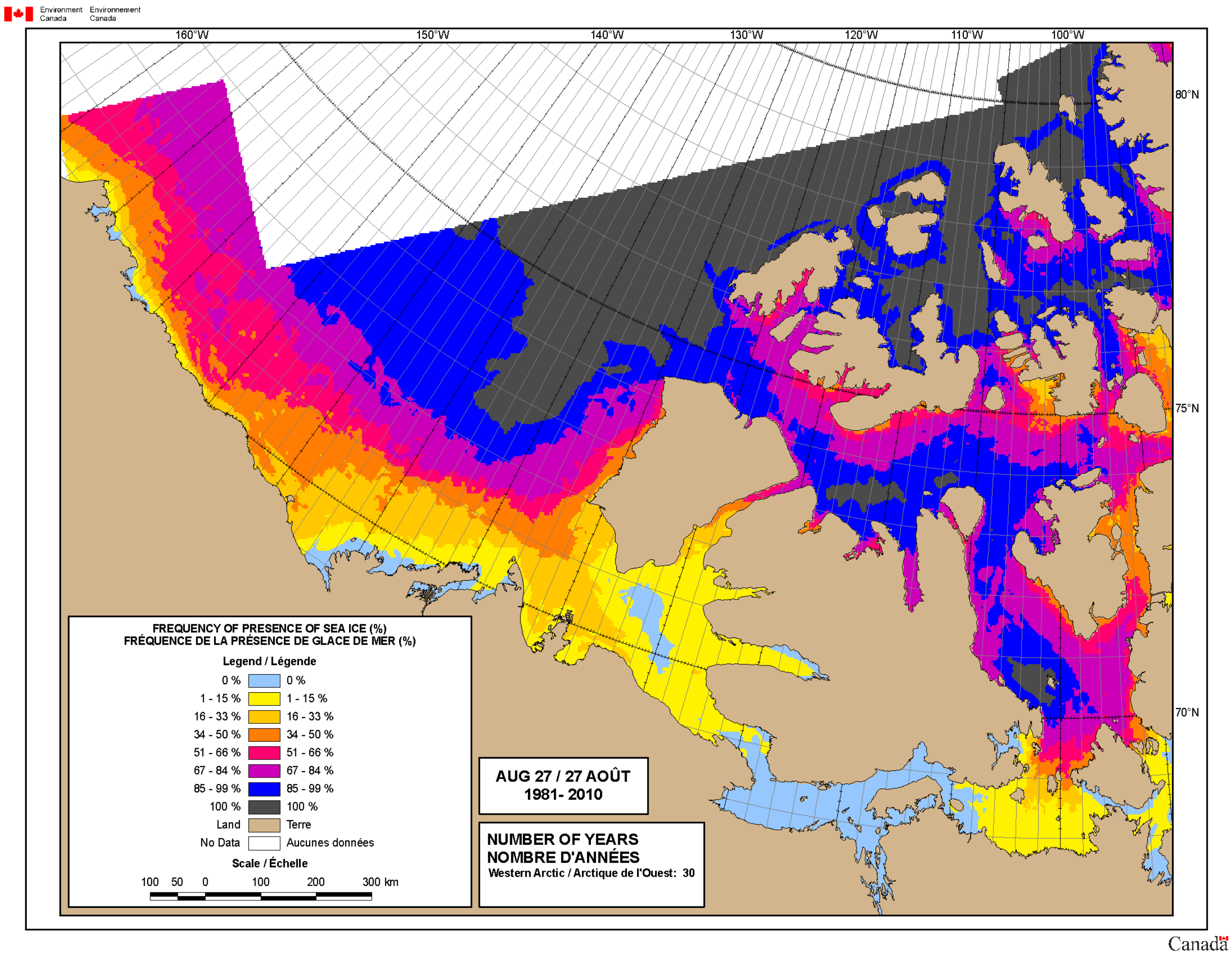

Figure 47: Map of historic frequency of sea ice presence in western Canadian arctic region for the week 08/27 seasons:1981-2014 (source: CIS, www.ec.gc.ca, 2015)

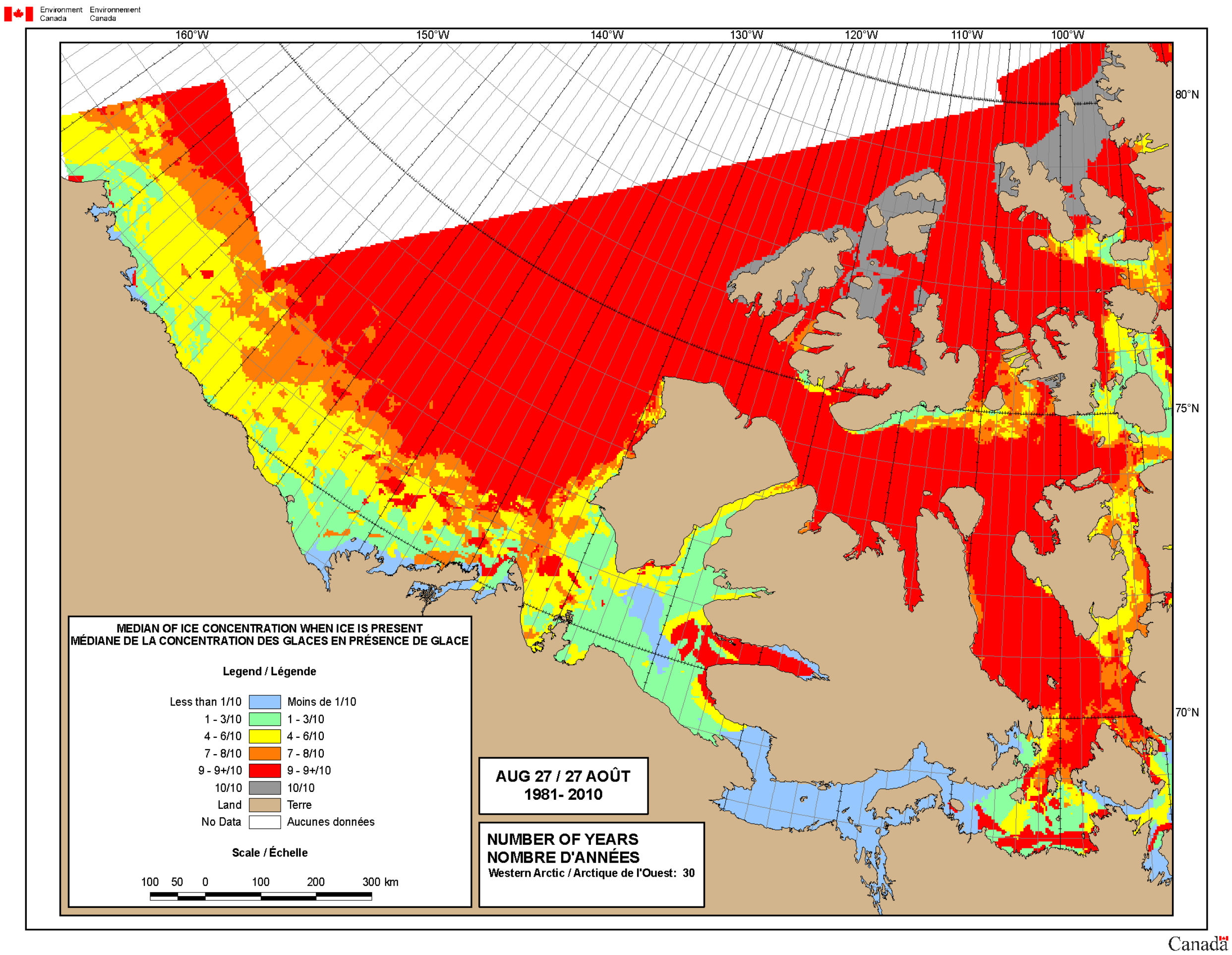

Figure 48: Historic median of ice concentration map for western Canadian arctic region for week 08/27 seasons: 1981-2014 (source: CIS, www.ec.gc.ca, 2015)

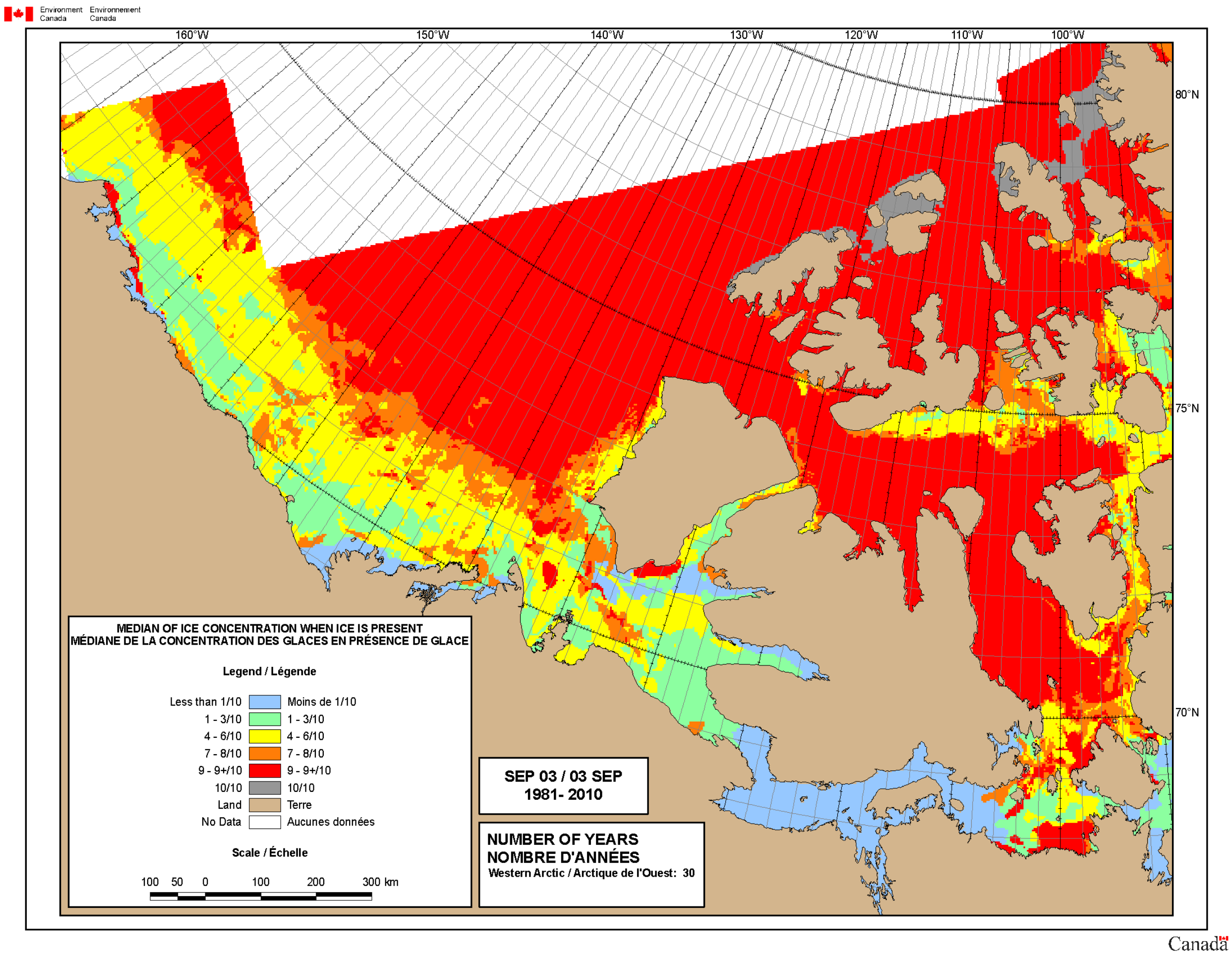

Figure 49: Historic median of ice concentration map for western Canadian arctic region for week 09/03 seasons: 1981-2014 (source: CIS, www.ec.gc.ca, 2015)

Annex III

The Egg Code

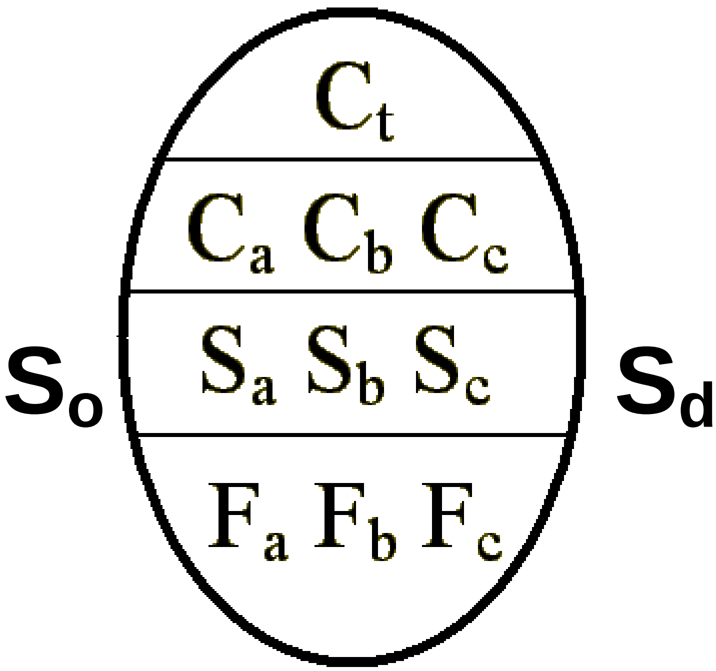

Figure 50: Egg code diagram (source: www.natice.noaa.gov, 2015)

C_t - Total concentration of ice in area, reported in tenths. May be expressed as a single number or as a range, not to exceed two tenths (3-5, 5-7 etc.)

C_a C_b C_c - Partial concentration (C_a, C_b, C_c) are reported in tenths, as a single digit. These are reported in order of decreasing thickness. C_a is the concentration of the thickest ice and C_c is the concentration of the thinnest ice.

S_a S_b S_c - Stages of development (S_a, S_b, S_c) are listed using the code shown in Table 1 below, in decreasing order of thickness. (NOTE: If there is a dot (.), all stages of development codes to the left of the dot (.) are assumed to carry the dot (.)) These codes correspond directly with the partial concentrations above. C_a is the concentration of stage S_a, C_b is the concentration of stage S_b, and C_c is the concentration of S_c.

S_o S_d - Development stage (age) of remaining ice types. S_o if reported is a trace of ice type thicker/older than S_a. S_d is a thinner ice type which is reported when there are four or more ice thickness types.

F_a F_b F_c - Predominant form of ice (floe size) corresponding to S_a, S_b and S_c respectively. Table 2 below shows the codes used to express this information.

Table 1. Egg Codes for Stages of Ice Development (S_x Codes)		
Stage of Development for Sea Ice	**Code Figure**	**Stage of Development for Fresh Water Ice**
New Ice-Frazil, Grease, Slush, Shuga (0-10 cm)	1	New Ice (0 - 5 cm)
Nilas, Ice Rind (0 - 10 cm)	2	
Young (10 - 30 cm)	3	
Gray (10 - 15 cm)	4	Thin Ice (5 - 15 cm)
Gray - White (15 - 30 cm)	5	Medium Ice (15 - 30 cm)
First Year (30 - 200 cm)	6	
First Year Thin (30 - 70 cm)	7	Thick Ice (30 - 70 cm)
First Year Thin - First Stage (30 - 70 cm)	8	First Stage Thick Ice (30 - 50 cm)
First Year Thin - Second Stage (30 - 70 cm)	9	Second Stage Thick Ice (50 - 70 cm)
Medium First Year (70 - 120 cm)	1.	Very Thick Ice (70 - 120 cm)
Thick First Year (>120 cm)	4.	
Old - Survived at least one season's melt (>2 m)	7.	
Second Year (>2 m)	8.	
Multi-Year (>2 m)	9.	
Ice of Land Origin	▲●	

Table 2. Egg Codes for Forms of Ice (F_x Codes)		
Forms of Sea Ice	**Code Figure**	**Forms of Fresh Water Ice**
	~F	Belts and Strips symbol followed by ice concentration
New Ice (0-10 cm)	X	
Pancake Ice (30 cm - 3 m)	0	
Brash Ice (< 2m)	1	
Ice Cake (3 - 20 m)	2	
Small Ice Floe (20 - 100 m)	3	
Medium Ice Floe (100 - 500 m)	4	
Big Ice Floe (500 m - 2 km)	5	
Vast Ice Floe (2 - 10 km)	6	
Giant Ice Floe (> 10 km)	7	
Fast Ice	8	Fast Ice
Ice of Land Origin	9	
Undetermined or Unknown (Iceberg, Growlers, Bergy Bits)	/	

Figure 51: Egg code diagram properties explanation (source: www.natice.noaa.gov, 2015)

Annex IV

Risk calculation per ice regime encountered during the ships course through NWP:

$RIO_Y = C * RIV = 8 * -3 = -24$, NO GO

$RIO_J = C * RIV = 9 * -3 = -27$, NO GO

$RIO_W = (C_1 * RIV_1) + (C_2 * RIV_2) = (2 * -2) + (7 * -3) = -25$, NO GO

$RIO_N = (C_1 * RIV_1) + (C_2 * RIV_2) = (5 * -2) + (5 * -3) = -25$, NO GO

$RIO_{DD} = C * RIV = 7 * -3 = -21$, NO GO

$RIO_P = (C_1 * RIV_1) + (C_2 * RIV_2) = (2 * -2) + (8 * -3) = -28$, NO GO

$RIO_{CC} = (C_1 * RIV_1) + (C_2 * RIV_2) = (2 * -2) + (6 * -3) = -22$, NO GO

$RIO_{LL} = (C_1 * RIV_1) + (C_2 * RIV_2) = (2 * -2) + (2 * -3) = -10$, GO with SLOW Speed Limitation

$RIO_{EE} = (C_1 * RIV_1) + (C_2 * RIV_2) = (6 * -2) + (1 * -3) = -15$, NO GO

$RIO_V = (C_1 * RIV_1) + (C_2 * RIV_2) = (3 * -2) + (6 * -3) = -24$, NO GO

$RIO_{NN} = C * RIV = 2 * -2 = -4$, GO with SLOW Speed Limitation

$RIO_{AA} = (C_1 * RIV_1) + (C_2 * RIV_2) = (6 * -2) + (2 * -3) = -18$, NO GO

$RIO_{HH} = (C_1 * RIV_1) + (C_2 * RIV_2) = (1 * -2) + (5 * -3) = -16$, NO GO